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THE MALE GENITAL TRACT OF TWO GENERA OF INDIAN SQUIRRELS

BY M. R. N. PRASAD

An exhaustive review of the literature concerning the genital tract of the squirrels has been given by Mossman, Lawlah and Bradley (1932). They have described the reproductive tracts of *Sciurus carolinensis*, *Sciurus niger*, *Tamias striatus* and *Tamiasciurus hudsonicus*, and have shown that a typical sciurid tract is characterised "by the presence of a pair of coiled, relatively little branched seminal vesicles (vesiculae seminales); a simple, compact, highly compound tubular prostate gland (glandulae prostaticae) opening by a single pair of primary ducts; and a pair of very large compound tubular Cowper's glands (glandulae bulbo-urethrales) with wide spiral ducts which constrict as they enter the corpus spongiosum of the bulb, but immediately after entering expand and then unite forming at this region of union a well-developed gland, the bulbar gland (glandula bulbi), of very different character of epithelium from that of true Cowper's glands. This bulbar gland drains through a single glandular penile duct which runs distalward through the corpus spongiosum ventral to the urethra to near or beyond the ventral flexure of the penis where it joins the urethra from the ventral side." Another work of importance is by Krölling (1921) who gives a complete histological and cytological account of the genital tract of *Sciurus vulgaris*. Siddiqi (1938) described the genito-urinary system of the Indian ground squirrel, *Funambulus palmarum*. His description, based mainly on that of immature individuals, shows that this species conforms in general to the typical sciurid type.

The glans penis and baculum are of particular importance as they show certain distinctive features in their morphology which are of classificatory value. Tullberg (1899) was the first to describe the glans of *Sciurus* (*Funambulus*) *palmarum* as a very unsymmetrical, short, club-like body covered over by a large number of papillae and provided with a well developed os penis. The fact that the appearance of the baculum can be of taxonomic importance, because it may show very striking variations in form between genera and families which otherwise appear much alike, was first pointed out by Thomas (1915). It was later elaborated by Pocock (1923) who, by a study of the external form of the glans penis and baculum of many genera of squirrels suggested a scheme

of classification based on penial characters. Hill (1936, 1940) described and figured the penis and its bone in the Ceylonese squirrels. Siddiqi and Lemasurier (1936) described the homology of the glans of the Indian ground squirrel, *Funambulus palmarum*.

Originally all striped squirrels and jungle squirrels were included under a single genus *Funambulus*. On penial characters, however, Pocock found it necessary to split the genus; and he accordingly accommodated them under two genera, *Funambulus* and *Tamiodes*. The characters of the two genera as described by Pocock are as follows: "*Funambulus*. Glans ending in a narrow elongated point supported by a distal portion of the baculum, the orifice to the right near the base of the slender portion and remote from the tip. Baculum a simple upcurved attenuated rod. *Tamiodes*. Glans thick, blunt, bilabiate distally. Orifice between the upper and lower lips, the lower secondarily subdivided. Baculum with its terminal portion bent vertically upwards and curved forwards with a prominent inferior angle."

Ellerman (1940) does not favor such a separation based mainly on penial characters, but prefers to retain the genus *Funambulus* for all striped squirrels until more species have been examined.

The reproductive tract of the Indian palm squirrel *Funambulus palmarum palmarum* differs in many respects from the normal sciurid type (Prasad, 1952), whereas that of *Funambulus palmarum* (= *F. pennanti?*) shows all the characters of a typical sciurid tract (Siddiqi, 1938). It is curious that such fundamental differences should exist even among forms now supposed to belong to the same genus. With this point in view I have undertaken a study of the male genital tracts of the Indian squirrels to note if characters of sufficient importance may be found to assess their interrelationships. I give in this paper an account of the genital tracts of the palm squirrel, *Funambulus palmarum palmarum* Linn., and the giant Malabar squirrel, *Ratufa indica maxima* Schreb.

MATERIAL AND METHODS

The palm squirrels were trapped alive by net in the vicinity of Bangalore. The Malabar squirrels were shot in the forests of Coorg and Mysore district. The genitalia were removed after the animals were shot or anaesthetised, and fixed in formalin, Carnoy, and Bouin's fluids. A gross morphological study of the tract was made by pinning it, in its natural position, on a paraffin slab after dissecting the constituent parts free of fat and connective tissue. To trace the course of the ducts a cold gelatin mass, colored with Berlin blue, was injected into the ducts. To follow the course of the ducts more carefully, serial sections of the colliculus seminalis region of the muscular urethra were cut at 10 micra and stained with Heidenhain's iron haematoxylin. The fibrous penis bulb and penis presented no difficulties in sectioning when the anilin-wintergreen oil method outlined by Mossman *et al.* (1932) was used. The glans penis with the os penis in situ, was decalcified in a solution of 3 per cent nitric acid in 70 per cent alcohol, cut at 15 micra and stained with Ehrlich's haematoxylin. Alizarin transparencies of the bacula were made from penes fixed in rectified spirit. Wax model reconstructions of the colliculus seminalis region and the adjoining genital ducts were made.

OBSERVATIONS

Palm squirrel. *Funambulus palmarum palmarum* Linn.—Plate I, upper left, gives a general idea of the gross morphology of the reproductive tract of an adult squirrel. As

there is no periodicity in sexual activity in the male (Prasad, 1951), the component parts of the reproductive tract do not undergo marked changes in size during the different months of the year.

Testis. The testes descend into a semipendent scrotum as the animals mature, and remain in this condition throughout life. The sexually mature testis reaches a maximum size of 15 x 20 mm. exclusive of the epididymis. It is covered over by a thin transparent shining tunica albuginea which shows a series of blood vessels running dorsoventrally in a spiral course in the form of distinct well marked stripes. The epididymis has three well defined parts, a caput and a cauda connected by a body which is applied to the testis over half its length. The caput and the cauda epididymis are heavily invested with fat. From the mesial side of the cauda proceeds a thick walled muscular vas deferens, which runs along the side of the testis, through the inguinal canal, to the prostatic region, and there curves round the base and side of the urinary bladder to enter the urethra at the region of the colliculus seminalis.

Prostate. The prostate is a compact, compound tubular gland lying in close approximation to the bladder. Its ventral side is flat in the cephalo-caudal direction but is convex laterally. The cranial end is rounded while the caudal end is grooved in the middle for the accommodation of the muscular urethra. A shallow sulcus in the dorsal part lodges the rectum. Lateral to the rectum, and placed in the same groove, are the ducts of the seminal vesicles. The prostate reaches a size of 13 x 9 x 6 mm. in length, breadth, and depth respectively.

The gland has a thin membranous capsule. The glandular substance is spongy, yielding, and pale yellow in color in a freshly cut condition. The prostate shows two clearly marked regions, a cranial peripheral unit of secreting tubules, and a caudal ventral unit of collecting tubules. From the capsule thin trabeculae of fibromuscular tissue extend inward and form the boundaries of the lobules. The lobules are formed of a closely packed network of glandular tubules. The secreting tubules lead into the collecting tubules at the posterior region of the gland. These then unite to form a pair of main ducts which ultimately penetrate the roof of the muscular urethra and run caudad, lateral to the ducts of the seminal vesicles. The gland lies completely outside the urethra. Hence a true prostatic urethra, such as occurs in man, does not exist. Prostatic concretions are not seen, even in the tubules of the older animals.

Seminal vesicles (Pl. I, upper left and lower left). The seminal vesicles are the most striking of the accessory glands, both in their size and appearance. They are highly branched tubular glands. The branching is very irregular and the tubules are held together by a thin and easily separable fibrous layer to form a mass of varied contours. There are two main lobes (Pl. I, upper left) each of which consists of highly ramifying tubules draining their products into two separate ducts which unite and run caudad along the sulcus in the prostate to the region of the colliculus seminalis. The tubules have a thick muscular coat and are lined internally by longitudinal ridges of mucous membrane. The lining epithelium is of the tall columnar type. The glandular portion, excluding the ducts, measures 8 x 15 x 16 mm. in depth, breadth, and length respectively. The tubules, which are always gorged with secretion, do not at any time have spermatozoa in them.

Muscular urethra (Pl. I, upper left). The muscular urethra is about 17 mm. long from the prostatic portion to the region of the bulb. It is about 4–5 mm. in external and 3–4 mm. in internal diameter. The major portion of the wall of the muscular urethra is made up of a thick continuous coat of striated circular muscle fibres. Towards the neck of the bladder and arising from the dorsal wall of the muscular urethra is a median fold, the colliculus seminalis, formed by the elevation of the mucous membrane and subjacent connective tissue (Fig. 5A). It is about 1.5 x 0.98 mm. in cephalocaudal length and height respectively. On the most elevated portion of the colliculus, along either side of the median line is a slit-like opening of the vas deferens. The prostatic ducts are most lateral. They run close to the ducts of the seminal vesicles placed between the prostatic ducts and the vas deferens. Behind the openings of the vasa deferentia, the prostatic duct bends inward and unites with the much wider duct of the seminal vesicle before the latter opens into the urethra. Since the vas deferens

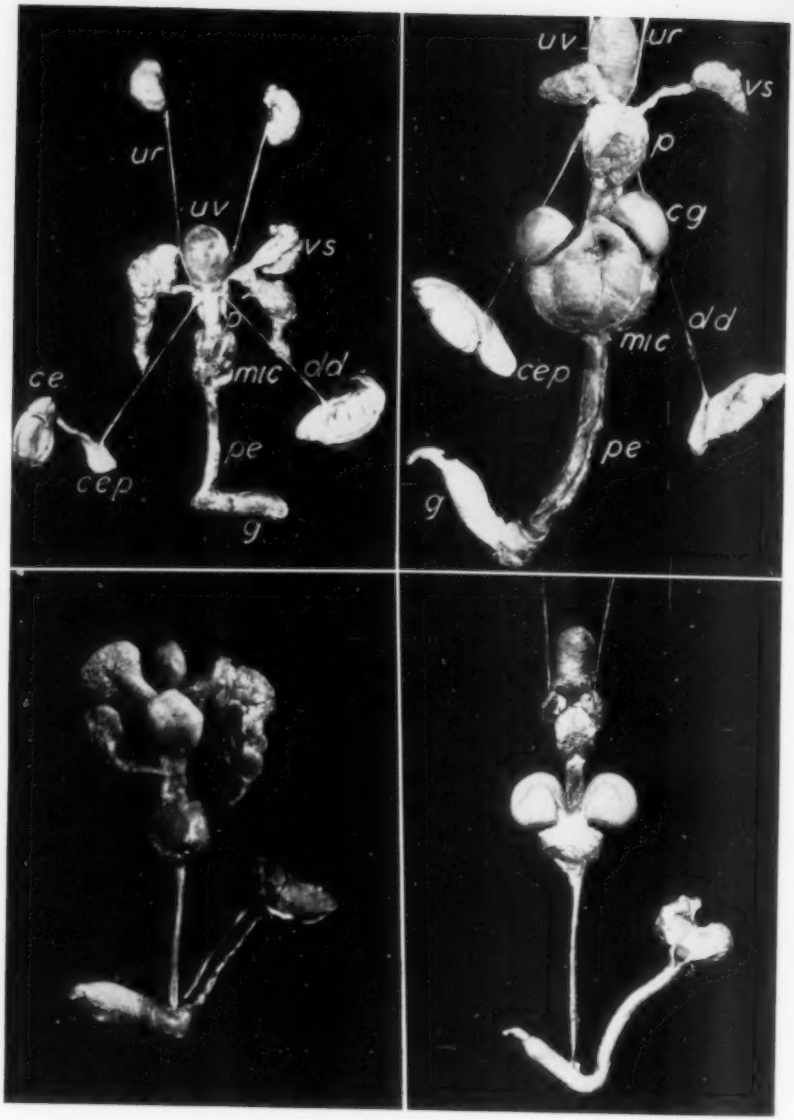

PLATE I

Upper Left: Ventral view of the urinogenital tract of the palm squirrel. The cauda epididymis has been separated from the testis on one side. The seminal vesicles have been separated to show the two lobes and the highly coiled nature of the tubules. The prepuce is cut to show the glans penis. Abbreviations: ce, caput epididymis; cep, cauda epididymis; dd, ductus deferens; mic, musculus ischiocavernosus; vs, vesicula seminalis; g, glans penis; p, glandula prostatica; pe, penis; ur, ureter; uv, urinary vesicle.

Upper Right: Dorsal view of the urinogenital tract of the Malabar squirrel. Abbreviations: cg, Cowper's glands; other abbreviations same as in Upper Left.

Lower Left: Penis of the palm squirrel and (Lower Right) the Malabar squirrel together with the accessory glands of reproduction. The corpus cavernosum penis has been separated from the corpus spongiosum penis up to the base of the glans penis. Dorsal views of accessory glands and muscular urethra.

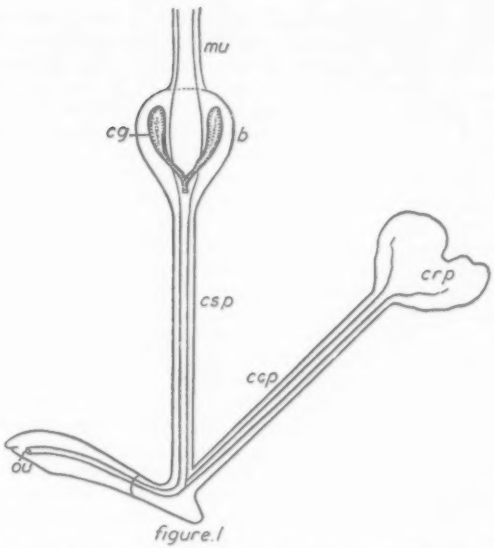

FIG. 1.—Diagram of the penis of the palm squirrel showing the position of the Cowper's glands, its ducts and the urethra. The glandular portion of the Cowper's glands is darkened while the urethra is shown by a thin line. The corpus cavernosum penis is separated from the corpus spongiosum up to the base of the glans penis. Abbreviations: b, bulbus penis; ccp, corpus cavernosum penis; cg, Cowper's glands; csp, corpus spongiosum penis; crp, crus penis; mu, muscular urethra; ou, opening of the urethra.

opens independently into the urethra, there is no ejaculatory duct. In a few rare cases a slight modification of the arrangement of the genital ducts is noticed. The vas deferens has its independent entry into the urethra. The opening of the prostatic duct into the duct of the seminal vesicle is oblique and very close to the opening of their common portion into the urethra.

Utriculus prostaticus (Fig. 5A). The utriculus prostaticus (uterus masculinus, vagina masculina) is a long tubular gland with glandular swellings at different levels and lies in the midsagittal plane. It opens into the urethra at the highest part of the colliculus seminalis midway between the orifices of the vasa deferentia.

Cowper's glands (Fig. 1). The Cowper's glands (glandulae bulbo-urethrales) are the least developed of the accessory glands in the palm squirrel. Gross examination of the genital tract reveals no trace of these glands. A study of the serial sections of the bulb, however, shows the presence of these glands in the form of patches of glandular tissue at the sides of the urethra, entirely enclosed by the musculature of the bulb. The ducts of the two glands unite towards the posterior end of the bulb, and enter the urethra from the ventral side. No trace of a urethral sinus or diverticulum is noticed in the bulb.

Bulbar gland and penile duct. Structures corresponding to the bulbar gland and penile duct are absent.

Penis (Fig. 1; Pl. I, upper left and lower left). The penis is about 52 mm. long from the region of the bulb to the tip of the glans. From the bulb it extends craniad for about 27 mm. close to the ventral body wall of the abdomen, and bends sharply caudad for 25 mm. showing a strong ventral flexure, a feature characteristic of the Sciuridae.

The penis begins in the pars bulbi region in the form of two bilateral crura. Each crus carries a large ischiocavernosus muscle as a sheath. The two unite just in front of the pubic symphysis to form the corpus penis. The corpus cavernosum penis is a laterally compressed body which shows a deep ventral groove completely filled by the corpus spongiosum. The corpus cavernosum is made up of a trabecular framework enclosed in a fibrous tunic. The corpus spongiosum is enclosed in a much thinner fibrous capsule and fills the ventral groove completely. The tissue of the spongiosum within the capsule and surrounding the urethra is erectile in nature. The penile urethra runs in the middle of the spongiosum. In the glans it runs asymmetrically to the right of the os penis and opens about 5 mm. from the terminal end of the glans (Figs. 1, 2A).

Typical measurements of the penis are: Length of the penis from tip to flexure, 25 mm.; length of the glans penis, 12 mm.; transverse diameter of the glans penis, 7 mm.; dorsoventral diameter of the glans penis, 7 mm.; and length of the baculum, 11.6 mm.

The glans penis (Fig. 2A, B; Pl. I, lower left) is cylindrical, smooth proximally, and tapers at the distal end. The dorsal part is slightly convex and bends down distally. There is a distinct bulge ventrally about 7 mm. from the terminal end. The portion of the glans in front of the preputial base is ornamented all around by a series of transverse fissures which are broken up and arranged irregularly. The globular part of the glans narrows to a flattened point at the terminal end. From the summit of the bulge, midventrally, arise two prominent elevated folds of skin supported by a dense core of elastic fibrous tissue, the inner pair of folds, which pass forward distally and meet round the tip. Terminally the edges of these two folds are bent outwards forming an open lip. The inner pair of folds forms the borders of an open ventral groove leading from the terminal open lip, obliquely to the right, to terminate in front of the opening of the urethra. From the summit of the bulge arises another pair of folds, the outer pair, each fold of which runs obliquely outwards towards the tip of the glans to meet the sides of the ventral lip. They form the borders of a shallow bay in which the inner pair of folds is lodged. The left half of the inner pair of folds is supported by the upper limb of the baculum.

The baculum (Fig. 2C, D, E) is a narrow rod about 11.5 mm. in length, flattened laterally. It is concave on the dorsal side and convex ventrally, the curvature gradually rising from the thick base to the distal extremity of the glans. The terminal end is clearly bifurcated. The left limb of the fork is short, rounded at the sides and has a distally directed protuberance, while the right limb is flat, slightly twisted, longer, sharply rounded at the tip and is directed dorsally. It supports a raised projection of the skin forming the right boundary of the open ventral groove. The urethra runs asymmetrically to the right, and opens on the right side of the baculum about 5 mm. from the terminal end.

Giant Malabar squirrel, *Ratufa indica maxima* Schreb.—The distribution and taxonomy of this form have been discussed at length by Wroughton (1911, 1920) and Robinson and Kloos (1918). The description of the genital tract is from individuals which were sexually mature and at the height of sexual activity.

Testis (Pl. I, upper right). In the seuxally mature adults the testes descend into a thick-skinned hairy scrotum, projecting back and hanging down from the pubic region. Each testis reaches a maximum size of 18 x 12 x 10 mm. in length, breadth, and depth respectively. The testis is ornamented by two pairs of prominent blood vessels arising from the dorsal and ventral surfaces which run obliquely and cross over in the middle. On the sides of these are a number of smaller vessels which run dorsoventrally in a spiral course in the form of faint streaks. The epididymis and vas deferens have the same disposition as in the palm squirrel.

Prostate (Pl. I, upper right, lower right). The prostate is less composite than in the palm squirrel. It consists of two bilaterally symmetrical separate lobes each of which is roughly bean-shaped in outline. The two lobes are held together by a thin membranous fascia which is easily removable allowing the lobes to separate. Ventrally the lobes are convex anteroposteriorly and gently slope on the sides forming a shallow depression for the muscular urethra. The gland measures 18 x 8 x 5 mm. in cephalocaudal length, breadth, and depth respectively.

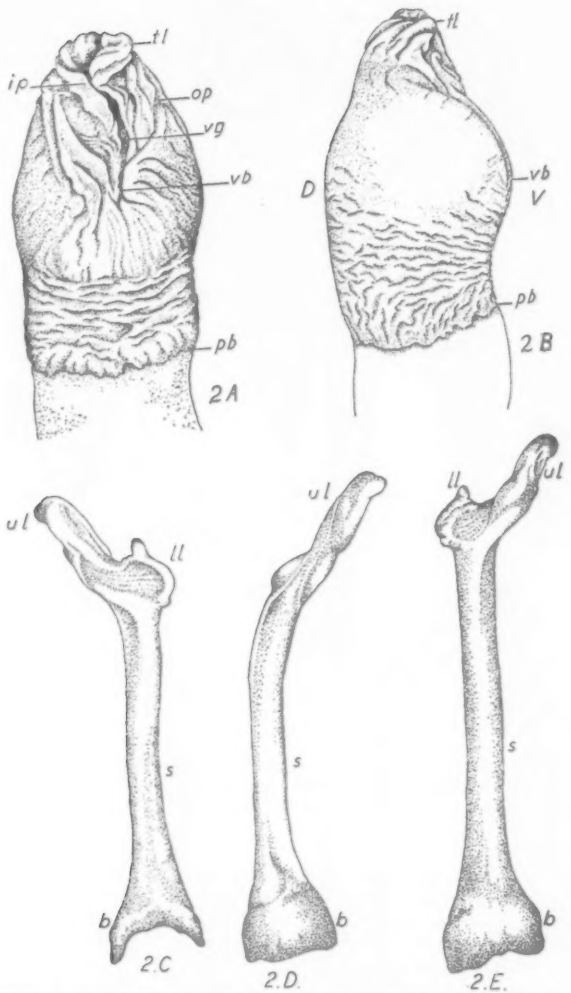

FIG. 2.—Glans penis and baculum of the palm squirrel. A. Ventral view of the glans penis × 4½. B. Lateral view of the glans penis. × 4½. C. Baculum. Ventral view. × 6½. D. Baculum. Lateral view. Left side. × 6½. E. Baculum. Dorsal view. × 6½. Abbreviations: b, base; D, dorsal; ip, inner pair of folds; ll, lower limb; op, outer pair of folds; pb, preputial base; s, shaft; tl, terminal lip; ul, upper limb; V, ventral; vb, ventral bulge; vg, ventral groove of the glans penis.

Seminal vesicles (Pl. I, upper right). These are in the form of coiled tubular glands. The cranial end is free and rounded while the base abuts aganst the lateral and cephalic portions, of the prostate. The gland attains a maximum size of 20 x 13 x 6 mm. in length, breadth and depth respectively.

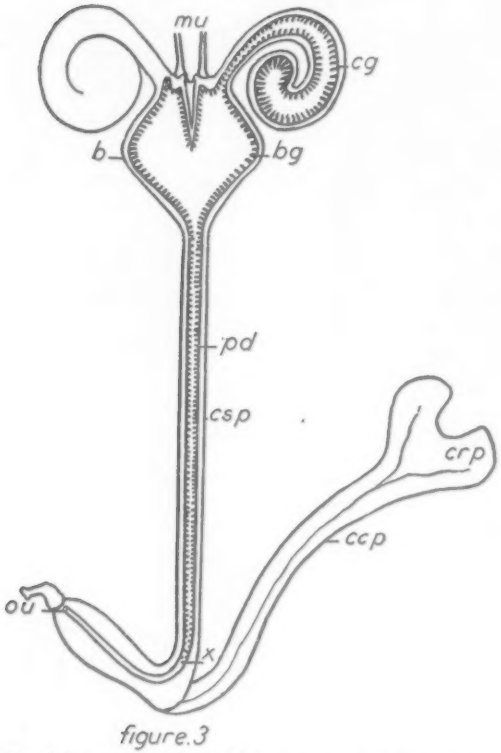

FIG. 3.—Diagram of the penis of the Malabar squirrel. Same arrangement as Fig. 1. The Cowper's gland, bulbar gland and penile duct are darkened. Abbreviations: bg, bulbar gland; pd, penile duct; X, union of the urethra and penile duct; other abbreviations same as in Fig. 1.

Muscular urethra (Pl. I, upper right, lower right). It is about 44 mm. long from the region of the prostate to the region of the bulb. At its anterior end its roof is pierced by the genital ducts which enter to join the urethra. It is about 9 mm. in external diameter. The thickness of the wall is made up of circular striated muscle fibres. The colliculus seminalis is well developed and bears the genital ducts. The vasa deferentia, the prostatic ducts and the ducts of the seminal vesicles unite before their entry into the urethra. In the cephalic part of the muscular urethra the prostatic ducts are lateral but before entering the colliculus bend inwards dorsal to the ducts of the seminal vesicles and run in the middle before uniting with the latter at the caudal end of the colliculus seminalis. The vasa deferentia join them immediately after to form a short duct which enters into the urethra. There is no trace of a utriculus prostaticus (Fig. 5C).

Cowper's glands (Fig. 3; Pl. I, upper right, lower right). These are the most prominent of the accessory glands and are the largest in size. They are placed dorsally on the lateral sides of the anus and occupy the angle between the bulbo-cavernosus and ischio-cavernosus muscles. The gland is roughly oval in outline measuring 17 mm. in cephalocaudal length and

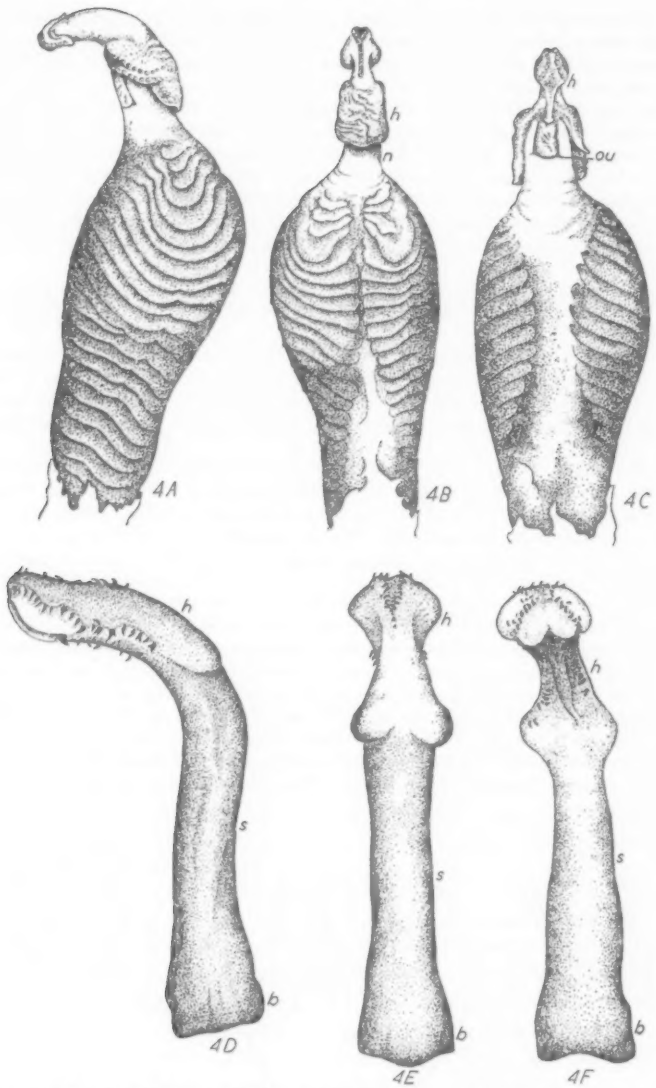

FIG. 4.—The glans penis and baculum of the Malabar squirrel. A. Glans penis. Lateral view showing the folds, neck and the hook. B. Glans penis. Dorsal view. C. Glans penis. Ventral view. D. Baculum. Lateral view. E. Baculum. Dorsal view. F. Baculum. Ventral view; all the views show the pointed spine like projections. Abbreviations: b, base; h, hook; s, shaft; n, neck, ou, opening of urethra.

16 mm. in transverse diameter. A long coiled duct arises from the ventrolateral side of each gland and enters the bulb from the dorsolateral side. In the sexually active males the gland and its ducts are filled with secretion which, in the preserved material, appears in the form of brownish, semi-hardened pliable wax.

Bulbar gland and penile duct (Fig. 3; Pl. I, lower right). As the two Cowper's ducts enter the bulb they enlarge to give rise to two glandular expansions, the bulbar glands. In the proximal part of the bulb the two bulbar glands are separate, but half way down they unite to give rise to a single gland which continues through the corpus spongiosum as a glandular duct, the penile duct. The penile duct runs ventral to the urethra in the corpus spongiosum and unites with it just proximal to the ventral flexure. There is no intermediate pouch in the bulbar gland. In this respect it resembles the condition in the chipmunk, *Tamias striatus* (Mossman *et al.*, 1932).

Penis (Pl. I, upper right, lower right). It is about 119 mm. long from the region of the bulb to the tip of the glans. The general disposition and structure is the same as in the palm squirrel.

Typical measurements of the penis are: Length of the penis from the bulb to flexure, 75 mm.; length of the penis from flexure to the tip of the glans inclusive of the hook, 44 mm.; length of the glans penis with the hook, 38 mm.; length of the hook, 13 mm.; dorsoventral diameter of the glans penis, 10 mm.; transverse diameter of the glans penis, 10 mm.; and length of the baculum, 17 mm.

The glans penis (Fig. 4A, B, C; Pl. I, upper right) is cylindrical with a terminal bulge from the distal end of which arises a short narrow process or "neck" inclined ventrally. The neck is succeeded by a "hook", broad at the base, narrow in the middle and tapering distally to a rounded knob. The hook is directed ventrally. It is ornamented by a number of small protuberances, pointed and bony in nature. The body of the hook is supported by the distal prolongation of the main shaft of the baculum. The opening of the urethra is in the form of a transverse slit placed ventral to the raised projection forming the neck. The body of the glans penis is sculptured by 22 folds of its outer skin. These arise from the dorso-median line and run outwards. Ventrally there is a smooth gap between the two sets of folds placed opposite to each other. The first three sets of folds from the distal end are small and are confined to the lateral portions of the terminal bulge of the glans. The last few folds near the preputial base are similarly smaller and do not reach the middle line. The rest of the folds, in between, arise from the dorso-median line and diverge out obliquely towards the ventral side. The thirteenth set of folds from the distal end is forked while the others are entire throughout their length. The edges of all the folds present a slightly frayed appearance.

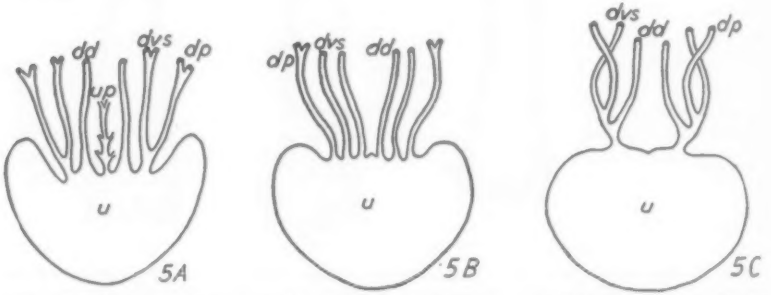

FIG. 5.—Diagrams of cross sections of the prostatic portion of the urethra and colliculus seminalis of: A. The palm squirrel; B. Ground squirrel (*Citellus tridecemlineatus*); and C. Malabar squirrel. Abbreviations: dd, ductus deferens; dp, ductus prostaticus; dvs, ductus vesicula seminalis; u, urethra; up, utriculus prostaticus.

The baculum (Fig. 4D, E, F) of the Malayan *Ratufa bicolor* is described by Dammerman (1931) and that of *R. macroura* by Hill (1936, 1940). The baculum is a well developed bone about 17 mm. in length from the base to the tip. The main shaft of the baculum is a stout rod, broad and hollowed at the base and tapering distally, measuring about 9 mm. in length. At the summit of the shaft is a ventrally directed hook which emerges at right angles from the shaft and extends to a length of about 8 mm. The hook is broad at the base, narrower in the middle and broadens again terminally to a rounded knob. The terminal part of the hook is beset with a row of sharp pointed projections starting from the sides and converging towards the dorso-median line where the two run approximately parallel to each other. The hook supports the similarly shaped process of the glans.

DISCUSSION

The male genital tract of the Sciuridae is of classificatory value as has been shown clearly in the case of the red squirrel *Tamiasciurus hudsonicus* Erxleben, by Mossman *et al.* (1932) and Mossman (1940). There is nothing in the teeth or any external character that gives a clue to its divergence from the typical members of the group. Pocock (1923) separated it from the genus *Sciurus* on account of the peculiar appearance of the glans which contained no os penis. Investigations by Mossman *et al.* showed that the male genital tract exhibited some fundamental differences from the normal sciurid type in the presence of minute Cowper's glands enclosed completely in the musculature of the bulb, in the absence of the bulbar gland and penile duct, and in the presence of a large true urethral sinus in the bulb. On the basis of these variations the red squirrel was placed in a separate subfamily *Tamiasciurinae*. In the light of the above findings it seems obvious that a general study of the genital tracts of all the members of the Sciuridae is essential for a clear understanding of their interrelationships and classification.

The classification of the striped squirrels also offers difficult problems. The genital tract of the Indian ground squirrel described by Siddiqi (1938) under the name, *Funambulus palmarum*, conforms in general to the typical sciurid type. It shows the following characters:

(1) The Cowper's glands are well developed and are placed on either side of the anal canal. Their ducts converge and join the median bulbar gland to form a single glandular penile duct.

(2) The prostatic utricle is completely absent.

(3) There are characteristic mucous folds in the muscular urethra. In the dorsal part of the muscular urethra is a semilunar fold with a pouch behind it; about 3 mm. below this fold is another identical semi-lunar fold with a second pouch behind it. The three genital ducts are conveyed on this second pouch on an elevation of the verumontanum.

(4) All the three genital ducts open independently into the urethra as in *C. tridecemlineatus* (Fig. 5B).

The palm squirrel, *Funambulus palmarum palmarum* Linn., examined by me shows certain features fundamentally different from the condition described by Siddiqi. The points of divergence are:

(1) The Cowper's glands are minute and are in the form of patches of glandular tissue on either side of the urethra completely enclosed in the musculature

of the bulb. Their ducts unite and open into the urethra from the ventral side in the bulb.

(2) The bulbar gland and penile duct are absent.

(3) The utriculus prostaticus is a long tubular gland extending in the mid-sagittal plane and opening into the urethra.

(4) Of the three genital ducts the vas deferens opens into the urethra independently, whereas the prostatic duct bends inward and meets the duct of the seminal vesicles before the latter opens into the urethra.

(5) Besides the colliculus seminalis there are no other muscular folds or projections into the muscular urethra.

In this connection it may not be out of place to mention that the term "palm squirrel" is applied to all the Indian striped squirrels. The south Indian species is *Funambulus palmarum* while the north Indian form is *Funambulus pennanti*. Wroughton (1905) who named the species *pennanti* states that the five-striped "Pennant's palm squirrel" is typical of north India and the three-striped *palmarum* is typically south Indian. Roonwal and Nataraj (1946) and Roonwal (1951) state that the only forms occurring in the north are the five-striped ones. Siddiqi (1938) who worked on the squirrels available in Allahabad (Uttar pradesh, North India) described them as the "Ground squirrels" under the name *Funambulus palmarum*. In view of the foregoing, it seems clear that the form described by Siddiqi must evidently have been a specimen of *Funambulus pennanti* Wroughton.

It is very strange that such fundamental differences should be noticed in forms now being treated as members of a single genus.

The Cowper's glands of the palm squirrel which are completely enclosed in the musculature of the bulb resemble the condition in the red squirrel *Tamiasciurus hudsonicus*. Their homology with the entirely different condition of the Cowper's glands in the other members of the Sciuridae has been explained by Barnstein and Mossman (1938). The bulbo-urethral glands and their ducts in the red squirrel are formed as dorsolateral diverticula from the proximal end of the ectodermal portion of the urethral plate as in the chipmunk *Tamias striatus* (Mossman, *et al.* 1932) and *Citellus tridecemlineatus* (Siddiqi, 1937), where the Cowper's glands and their associated ducts, bulbar gland and penile duct are large and well developed in the adults.

Great differences in the morphology of the glans penis in the groups of forms which show external resemblances have been shown by Thomas (1915), Pocock (1923), and Hill (1936, 1940). The glans penis of the Indian palm squirrel *F. palmarum palmarum* differs from the description by Pocock for *Funambulus*, the Indian palm squirrel. He described the glans as "a long rod, subcylindrical proximally, and swollen and spongy in texture, distally ending in a narrow attenuated process arising from the spongy globular part." It also differs from Hill's account of the glans penis of the Ceylonese palm squirrel *F. p. favonicus* which is described "as a long rod consisting of a smooth proximal portion and an apical globular part, the two being separated by a faintly constricted neck."

The ornamentation by fissures is also different. No mention is made of the terminal open lip and the ventral groove leading to the opening of the urethra characteristically noticeable in the species described by me.

The nature of the baculum also differs considerably. In the Ceylonese palm squirrel (Hill, 1936) the upper limb is long and hooked at the tip in the subspecies *brodei* and in the subspecies *favonicus* it forms a separate pointed ossicle. Pocock described the baculum of *Funambulus* as a simple rod, convex dorsally and ending in a pointed tip. The bone in *Tamiodes* is described by him "as a curved rod with a terminal bend at right angles to the main body of the shaft, distally expanded to form two processes, a smaller and a larger one." Though the last part of the description is almost the same as in the palm squirrel studied by me, the course of the curvature in *Tamiodes* is entirely different.

On the basis of the description by Pocock, the Indian palm squirrel *F. p. palmarum* would occupy a position intermediate between the genera *Funambulus* and *Tamiodes*. The peculiar points of divergence noticed in the genital tract are in favour of shifting *F. p. palmarum* from its present position. Reviewing the penial characters of the Ceylonese squirrels, Hill (1936) remarked, "the striped squirrels, on the contrary, form a difficult problem. According to Pocock's description the races of *palmarum* would fall into the genus *Tamiodes* whilst *layardi* with its conical appendage on the tip of the glans would fall into *Funambulus*. Probably *sublineatus* on the characters of its glans falls between the two, though on its baculum, it would require a new genus. It seems almost absurd that geographical races of what would otherwise be regarded as one and the same species should on penial characters require separate genera, though theoretically one is bound to admit that this is the correct procedure. Until more species have been examined in this connection it is best to retain *Funambulus* for all striped squirrels, despite their penial differences." Howell (1938) opined that in the absence of trenchant cranial characters, the morphology of the baculum alone should not be considered of generic value. Ellerman (1940) observed in this connection ". . . but whereas differences in the baculum may be valid as regards solving the problem whether two forms belong to the same genus or not, I am strongly of opinion that no generic names based solely on the shape of this organ can be retained."

There can be no doubt that *Funambulus palmarum palmarum* is very different from the other striped squirrels. In agreeing with the opinions of Hill, Howell, and Ellerman, I am inclined to feel that the consideration of a large number of significant differences in the genital tract taken as a whole would be a valid reason for shifting it from its present position. Failing this, in the light of the present findings, it is essential to redefine the present status of *F. p. palmarum* in particular and the genus *Funambulus* in general. This can be attempted only after a comparative study of the genital tracts of all the other existing genera of Indian and Ceylonese squirrels. This problem is engaging my attention and continuous efforts are being made to secure the specimens.

SUMMARY

The genital tracts of the palm squirrel, *Funambulus palmarum palmarum* Linn., and the giant Malabar squirrel, *Ratufa indica maxima* Schreb., are described.

The genital tract of the palm squirrel shows the following characters: The prostate is a compound tubular gland lying completely outside the urethra. The seminal vesicles are large branching tubular glands. The Cowper's glands are minute and are in the form of patches of glandular tissue on either side of the urethra completely enclosed in the musculature of the bulb. Their ducts unite and open into the urethra within the bulb. Bulbar gland and penile duct are not present. Of the genital ducts, the vas deferens opens independently into the urethra, the prostatic duct and the duct of the seminal vesicles unite and have a common entry into the urethra. The utriculus prostaticus is a long tubular gland opening into the urethra. The glans penis is provided with two pairs of prominent folds, an outer and an inner pair arising from the summit of a ventral bulge. The inner pair of folds forms a terminal open lip. There is an open ventral groove leading from the terminal open lip to the opening of the urethra. The baculum is a flattened rod with a terminally forked tip.

The genital tract of the giant Malabar squirrel is of the typical sciurid type. The bulbar gland has no intermediate pouch. There is a long glandular penile duct opening into the urethra just behind the ventral flexure. The three genital ducts unite and open into the urethra by a common opening.

There are significant differences between the genital tract of the palm squirrel and that of the Indian ground squirrel described by Siddiqi, both belonging to the same genus *Funambulus*. In view of these differences it is felt that the palm squirrel *F. p. palmarum* should be shifted from its present position, or its relationship with the other members of the genus redefined in the light of the present findings.

Acknowledgements.—It is with pleasure and gratitude that I acknowledge my indebtedness to Professors B. R. Seshachar and H. W. Mossman and to Dr. L. S. Ramaswami for their valuable suggestions and criticism and to Sri. R. Anand and Sri. Veerabhadraiah for the illustrations and the photographs.

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ANTLERS IN FEMALE DEER, WITH A REPORT OF THREE CASES IN *ODOCOILEUS*

By George B. Wislocki

Female deer usually do not bear antlers, excepting the members of the genus *Rangifer* (reindeer and caribou) in which the females normally possess antlers, although their head furnishings are smaller than those of the males. However, in some species of deer occasional does are encountered that have antlers. Antler-bearing females are relatively common in the European roe deer (*Capreolus capreolus*) and red deer (*Cervus elaphus*), as well as in the whitetail, blacktail and mule deer of the North American genus *Odocoileus*. These genera as well as *Rangifer* (in which the females normally possess antlers), belong to the telemetacarpal Cervidae, whereas, in plesiometacarpal deer, according to Rörig (1899, 1907), antlered does are rarely encountered.

Antlered does of the genus *Capreolus* usually bear small, poorly developed, irregular "freak" antlers which remain for the most part permanently in the velvet without being shed. Rörig (1899, 1907) assembled and classified many of the cases reported in the literature and pointed out correlations between them and the state of the reproductive tract. According to him, antlered does are divisible into groups with reproductive tracts showing (1) no recognizable pathology and seemingly normal, (2) diseased or atrophic ovaries, usually of unknown causation, (3) ovarian atrophy associated with senescence, (4) ovotestes (true hermaphrodites), and (5) rudimentary testes, located abdominally and having no recognizable ovarian component (pseudohermaphrodites). The condition of the reproductive tracts in a group of hermaphrodites of the genus *Capreolus* is illustrated in Figure 1, the diagrams have been constructed from data cited by Rörig. Few of the gross findings reported by Rörig appear to have been actually verified by microscopic examinations. He offered the interesting information that the relative size and degree of abnormality of the antlers are directly related to the degree of the abnormality of the reproductive tract and to the relative amount of testicular tissue encountered. Thus, does with ovaries showed the least degree of antler formation. Those bearing ovotestes (true hermaphrodites) exhibited greater antler proliferation, whereas those bearing only testicular rudiments (pseudohermaphrodites) showed the greatest degree of antler development. Moreover, in the latter group, a few animals gave evidence of occasionally shedding and renewing their antlers, thus manifesting cyclical antler control. In those hermaphrodites in which shedding occurred, the antlers were said always to possess a corona, which was not the case when the antlers were permanently retained. Rörig also reported the occurrence in two red deer (*Cervus elaphus*) of pseudohermaphrodites which had deformed horns.

Of the true hermaphrodites the majority were "lateral" hermaphrodites with a testis rudiment on the left side of the body cavity and an ovary on the right side. Pseudohermaphrodites (bearing testicular tissue only) were more prevalent than true hermaphrodites. With the exception of pseudohermaphrodites, Rörig

cited evidence indicating that many of the antlered does had been fertile and had given birth to young. Shedding of the antlers was said to occur frequently at the time of parturition. The presence of antlers themselves, he remarked, had no influence on fertility.

Rörig came to one quite erroneous conclusion, which need not be dwelt on here, to the effect that unilateral atrophy or lesions of either ovaries or testicles may result in abnormality and partial suppression of antler growth on the contralateral side. His concept of influences of gonadal injuries exerted on opposite halves of the body has been effectively refuted by Tandler and Grosz (1913) and Jaczewski (1952).

Abnormal antlers have also been reported in does of the genus *Odocoileus* (whitetail, blacktail and mule deer) of North America (Caton, 1877; Seton, 1909; Dixon, 1927; Berry, 1932; Cowan, 1936, 1946), but such reports have seldom been accompanied by any examinations of the reproductive tracts. Caton (1877) reported from wide experience that antlered does always possess small spike antlers which remain in the velvet. He concluded that the growth of antlers in does is incomplete, resembling the antlers of castrated bucks which remain in the velvet and never mature. Furthermore, he suggested, that the induction of antlers in female deer may be caused by "some peculiarity of the ovaries or some other of the genital organs".

Dixon (1927) observed a doe mule deer (*Odocoileus hemionus hemionus*) with antlers that were gnarled and malformed with no indication (on Sept. 11th) that the velvet would have been shed. Of this animal's pelvic organs he stated merely that the bladder [*sic*] (uterus?) and urinary organs were normal. He observed two further female mule deer from the same locality with forked antlers that were normally and symmetrically developed, brown, hard and completely out of the velvet. These, he stated, could be matched by similar male antlers. There was no evidence noted, he remarked, that would lead one to believe that their reproductive tracts were aberrant, although the internal genitalia were not examined.

Berry (1932) described an antlered blacktail doe (*Odocoileus hemionus columbianus*) suckling a fawn. Its horns comprised several spikelets about "the diameter and length of a lead pencil". He stated further, that in the last 80 years old residents in the locality had reported the sporadic occurrence of 12 or 14 does possessing antlers.

Cowan (1936) listed four does (genus *Odocoileus*) with perfect antlers in the collection of the University of California Museum of Vertebrate Zoology. Two of these specimens had normal forked antlers, a third had forked antlers and aberrant snags, and the fourth had typical three-point antlers. Cowan also cited an instance known to him of a captive female mule deer which manifested all of the anatomical and behavioral characteristics of a functional male. It haa spike antlers when captured, which were then shed at the normal time and replaced by a pair of forked antlers. During the rutting period this "doe" developed a swollen neck, a belligerent disposition and other male behavior. Although nothing was learned about the configuration of the internal genitalia of any of these

deer, Cowan (1936, 1946) assumed that the last one, which behaved as a male, must be a hermaphrodite, and that the hormone secreted by the testes had induced the changes noted, including the development of antlers of the male type. He asserted also that the most frequent type of antlered doe is one in which perfect antlers of the normal type are developed and that animals of this kind are infertile.

In addition to these five does, Cowan (1946) described an antlered, female mule deer killed on June 12th that possessed a single spike antler on the left side. Despite the fact that it had only one antler, he interpreted the presence of a well-developed corona as an indication that the antler was of the normal male type and would have matured in due course and would have shed the velvet. The reproductive tract, ovaries and mammary gland were reported as being normal in every respect, including the presence of twin fawns in the uterus. Of this animal Cowan remarked that it is the first case which he had encountered of a sexually normal doe with a "male type" antler. He found the condition of this animal difficult to reconcile with his previous assumptions.

MATERIAL

In view of the above considerations it has been of interest to learn something of three additional, antlered, whitetail does (*Odocoileus virginianus borealis*). The antlers and reproductive tracts of two of these deer were presented to us through the generosity and interest of Mr. James R. Reilly, Game Pathologist in the Conservation Department of the State of New York. The first was

FIG. 1.—Examples of the reproductive tracts of antlered does of the European roe-deer (*Capreolus capreolus*) reconstructed from cases collected by Rörig (1907). A, B and C: true lateral hermaphrodites. D: true hermaphrodite with ovotestes. E and F: pseudo-hermaphrodites. Abbreviations: R., right; L., left; Clit., clitoris; C., cervix; Epy., epididymis; Hy., hymen; Ov., ovary; Phal., phallus; S.V., seminal vesicles; Test., testis; Ur., urethra; U.G., Urogenital canal; Ut., uterus; V., vagina; V.D., vas deferens.

A. Case 26 (*loc. cit.*, p. 28). True testis and epididymis without spermatozoa, which were larger than the normal-sized ovary. The short left uterine horn ended blindly. Running the length of the uterus from testis to vagina there was a vas deferens which terminated blindly. External genitalia normal. The antlers, covered by velvet, were 4 cm. high. B. Case 27 (*loc. cit.*, p. 28). Normal ovary on right; degenerated testis and epididymis present on left side. Enlarged clitoris. Lactating mammary glands. Possessed spike antlers in velvet. The antlers were subsequently shed at an abnormal time, but were again renewed and remained in the velvet. Animal became pregnant and gave birth to a fawn. C. Case 30 (*loc. cit.*, p. 29). Ovary and uterine horn on right; small testis and epididymis on left. Mammary glands well developed. Accompanied by fawn. No remarks about antlers. D. Case 37 (*loc. cit.*, p. 34). On each side, a well-developed ovary in close proximity to a testis—devoid of spermatozoa. Epididymis not mentioned. No vas deferens. Tubes and uterus normal. External genitalia exhibited the rudiment of a penis. Possessed normal forked antlers each bearing three points which had shed their velvet (*loc. cit.*, Fig. 15). E. Case 20 (*loc. cit.*, p. 30). Bilateral abdominal testis and epididymis, associated with vasa deferentiae and a bicornuate uterus the horns of which ended blindly. Distinct seminal vesicles. Antlers, 17 cm. high, each bearing three points and devoid of velvet. F. Case 23 (*loc. cit.*, p. 31). Right testis located in groin; vas deferens extending towards uterus and ending blindly. Left testis rudimentary. Rudimentary bicornuate uterus. A rudimentary penis. Branched antlers covered by velvet.

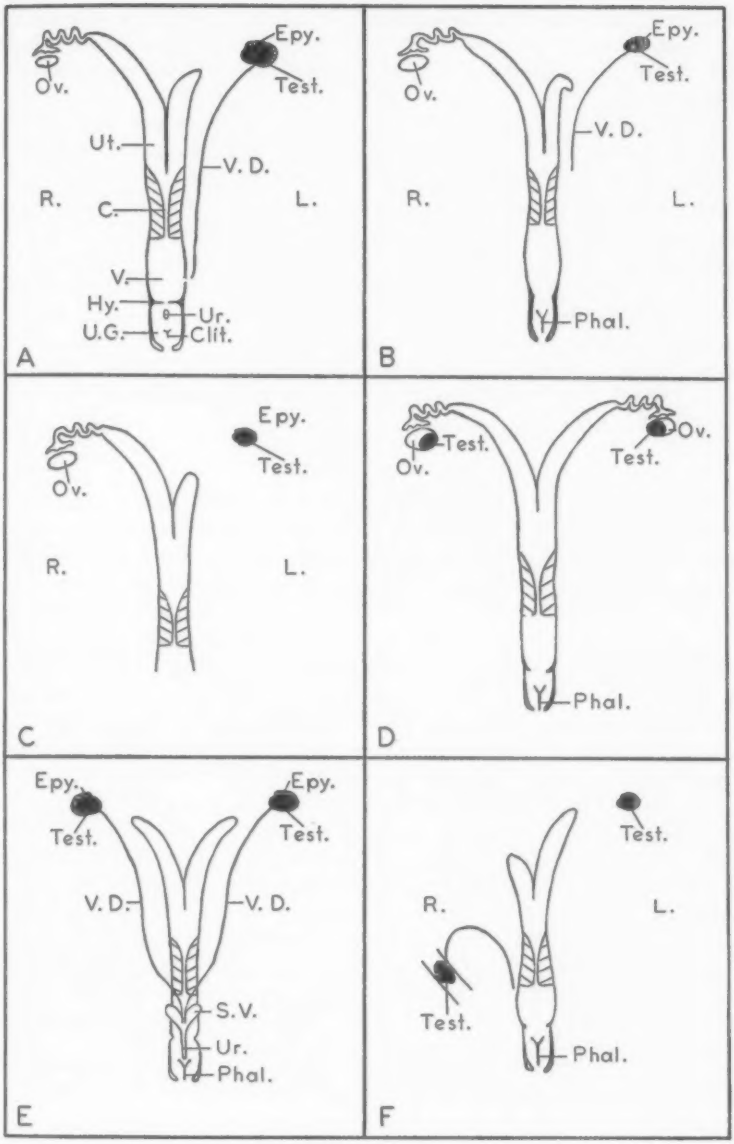
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FIG. 1

killed by an automobile in Chautauqua County, N. Y. on November 11, 1951. The frontal portion of the skull carrying one antler in velvet, the reproductive tract, the pituitary gland and the udder were placed in 10 per cent formalin on November 28th.

The second doe was shot on November 22, 1951 in Albany County, N. Y. Its skull plate carrying an abnormal antler in velvet, the adrenal glands, and the udder were immediately placed in 10 per cent formalin.

The third doe, killed on July 8 in a highway accident in Michigan, was brought to my attention through the interest of Mr. L. D. Fay, Game Pathologist in the Department of Conservation of the State of Michigan. The doe was described by the conservation officer who made the collection as having irregular antlers which were in the velvet: one was about four inches long with one point, while the other was seven inches long with a prong at the end. She was not pregnant at the time of death, but milk was present in the udder. The ovaries, which were removed and placed in 10 per cent formalin, were submitted for examination.

OBSERVATIONS

The skull of the first doe (OV-51-2) killed in November bore a spike horn on the left side. This spike, about 9 cm. long, was completely covered by healthy appearing velvet. At its base it was about 1½ cm. in width and completely devoid of any apparent pedicle or corona. On the opposite side of the frontal bone in a corresponding position, beneath the hair, the finger could palpate a distinct bony elevation not ordinarily evident in females.

The external reproductive opening seemed to be normal. Internally, there was a very small, but nevertheless well-shaped bicornuate uterus with small fallopian tubes. There were no discernible rudiments of male organs. The ovaries were quite minute, measuring 1.5 x 0.5 x 0.4 cm. in size. They were solid, except for a cyst 3 mm. in diameter located in the right ovary. On microscopic examination they were found to consist of ovarian stroma with quite a number of primary follicles that contained recognizable eggs situated in the ovarian cortex which was densely infiltrated with mononuclear leucocytes. The preservation was extremely poor, so that no great detail could be made out. It was obvious, however, that the ovaries were quite atrophic, possessing no secondary follicles. One small ill-defined area in the left ovary appeared to be a corpus luteum in a state of marked regression. A few minute corpora albicantia were also visible. A small cyst was present in the right ovary. It was reported that this animal's udder contained milk at the time of death, a finding that was confirmed upon microscopic examination of the organ.

The pituitary gland appeared to be of normal size and configuration and did not show any gross indications of pathology.

The skull of the second doe (OV-51-3), also killed in November, bore on the right side a main forked antler and just anterior to it a shorter subsidiary spike, both arising from a low irregular osseous protuberance of the frontal bone concealed by hair (Pl. I). The forked main beam and secondary spike, presented

PLATE I

UPPER: Abnormal antler development in a female, whitetail deer.

LOWER: A histological section of one of the ovaries of an antlered, whitetail doe, showing a large, pale-stained, regressing corpus luteum and a secondary follicle. The ovaries of this animal appeared to be normal and functionally active. × 20.

three points, 13, 12 and 9 cms. respectively in length, and were covered by healthy looking velvet. Although the low bony protuberance bore some slight resemblance to a pedicle, there was no clearly defined corona. The large base, however, suggested that other prongs might have existed, but had been lost by freezing and breaking off in previous winters. On the left side there was no indication of antler development.

The bicornuate uterus of this animal appeared to be about normal in size and shape with well-developed tubes and ovaries. There were no signs of any male organs. The ovaries seemed grossly normal, measuring about 2 x 1.5 x 1 cm. in dimension. A microscopic section through each one revealed a recent corpus luteum. Mr. Reilly, who reexamined the ovaries by the method of Cheatum (1949) after preparing further microscopic sections, identified an additional regressing corpus luteum in each ovary. Since the doe was lactating at the time it was killed, the regressing corpora lutea were ascribed to the preceding pregnancy.

The adrenal gland of the second animal seemed entirely normal in shape and size, cortex and medulla being regularly arranged without any gross indications of adenomatous or other pathological changes.

Of the third antlered doe only the ovaries were available for examination. They were grossly normal, and approximately the same size as those of the preceding doe. Examined according to the technic of Cheatum, each ovary contained a large regressing corpus luteum (Pl. I), referable to an antecedent pregnancy responsible for the observed lactation. A number of normal primary and secondary follicles as well as corpora albicantia were also present. From the findings it appears that the ovaries were normal and functionally active.

DISCUSSION

The reproductive tracts and antlers of three female whitetail deer are described. From the fact that all of the animals were lactating and the ovaries contained corpora lutea corresponding to a preceding pregnancy, the conclusion seems valid that the does were fertile and had produced young. The ovaries of two of the animals appeared to be completely normal, whereas those of the third were markedly atrophic. Nevertheless, the presence in the latter of a regressing corpus luteum and of milk in the udder, indicated that its ovaries must have been functional in a preceding pregnancy.

The antlers of the three deer were similar, being small and malformed. Those of the two deer killed in November were distinctly abnormal in that they were still in the velvet.

The author is familiar with ten other cases reported in the literature of antlered does in the genus *Odocoileus* (Dixon, 1927; Berry, 1932; Cowan, 1936, 1946). Only one of these accounts gives any information regarding the state of the reproductive tract (Cowan, 1946), another describes the doe as suckling a fawn (Berry, 1932) and a third remarks that the doe exhibited male behavior (Cowan, 1936). In seven of the ten cases the antlers were reported as being well-developed, and in three cases as small and malformed. Of one doe, bearing

"male" type antlers, it was reported that the spike antlers were shed and renewed (Cowan, 1936).

The three does reported here, added to the previous ones, make 13 in all, six of which had small malformed antlers and seven of which had well-developed antlers. Analysis of these cases indicates that five of the animals with malformed antlers were fertile females which were capable of bearing young. Of the seven does bearing well-formed or "male" type antlers, nothing was recorded about their reproductive history, except that one was said to have manifested male behavior (Cowan, 1946). It would have been interesting to determine whether the seven does bearing well-developed antlers were either pseudohermaphrodites or true hermaphrodites as Rörig has claimed is the case in *Capreolus*. With this in mind examinations of the reproductive tracts of other antlered does of *Odocoileus* would be desirable. For the present we have the sole evidence that does bearing small, malformed antlers are as a rule fertile and capable of bearing young.

There is good experimental proof which indicates that antler growth in male whitetail deer is controlled by the interaction of hormones derived from the testes and the anterior lobe of the hypophysis (Wislocki, 1943; Wislocki, Aub and Waldo, 1947; Waldo and Wislocki, 1951). The latter appears to be responsible for initiating antler growth, whereas testosterone regulates the maturation of the antlers and the shedding of the velvet. Furthermore, it has been shown that an initial triggering of the hypophysis by the testes is necessary early in life to initiate and set the antler cycles in motion.

Nothing is known concerning the hormonal factors regulating the growth of antlers in female reindeer or the sporadic occurrence of antlers in other deer. In female reindeer, which normally bear antlers, one might assume that some one of the ovarian ketosteroids plays a role similar to that of testosterone in the male. That this could be progesterone, the corpus luteum hormone, is suggested by recent experiments (Greene, Burrill and Ivy, 1939; Green, Burrill and Thompson, 1940) which demonstrate that this hormone has a definite androgenic effect on the prostate and seminal vesicles of immature castrated rats. Similarly, Chester Jones (1952) has shown that the ovaries of mice produce an androgenic substance that modifies the development of the female adrenal cortex.

In regard to the sporadic, antlered does of other species several speculations might be advanced. In the case of hermaphrodites bearing ovotestes or rudimentary testes, (Fig. 1) testosterone might be accepted as triggering the hypophysis and by its continuing secretion as subsequently bringing about the shedding of the velvet. But in does in which ovarian tissue alone appears to be present and the antlers are small and fail to shed the velvet, one would have to assume some temporary androgenic activity of the ovaries. Growth of small, abnormal antlers of this type has been induced experimentally in male whitetail deer that were castrated as fawns, as well as in normal does, by administering a single priming dose of testosterone (Wislocki, Aub and Waldo, 1947). One such doe, bearing experimentally induced antlers, became pregnant on two occasions. In this connection it should be noted that the ovaries of rats, mice

and other mammals, including the human, are capable of producing androgens (cf. Chester Jones, 1952). In mice, for example, the ovaries of aging virgins, specifically the corpora lutea in their transitorily active stage at proestrous and during the first pregnancy, produce an andromimetic steroid substance capable of inhibiting the x-zone of the adrenals (Chester Jones, *loc. cit.*). In view of these findings it may be no mere coincidence that a number of the antlered does bearing functional ovaries had apparently been through a pregnancy, during which an andromimetic steroid or progesterone may have triggered the hypophysis, as a result of which antlers had grown. But, since the existence of the corpus luteum of pregnancy is temporary, the release of androgenic hormone must have been relatively brief with the result that, as in castrated males, the antlers never subsequently matured or shed their velvet.

At present these tentative speculations are all that we can suggest to explain the growth of antlers in does. It is hoped that the review of the literature and the account of the antlered does presented here will stimulate others to report more cases with particular reference to the condition of the reproductive tracts.

SUMMARY

With the exception of reindeer, female deer do not possess antlers. However, antlers occur sporadically in other genera, especially in *Capreolus* and *Odocoileus*. In the former the size and condition of the generally abnormal antlers has been correlated to some degree with the condition of the reproductive tract, the largest antlers occurring in does which are either true hermaphrodites or pseudohermaphrodites and are infertile.

In *Odocoileus* the reproductive tracts of antlered does have not been hitherto examined. In the present paper the reproductive organs of three antlered does are described. Two of these does with completely normal appearing ovaries and lactating udders seem to have been fertile and capable of bearing young. Although the ovaries of the third doe were atrophic, microscopic examination revealed evidence of previous ovarian activity and the udder contained milk. These findings indicate that this animal, too, was fertile and had borne young. The antlers of these otherwise seemingly normal females were small, abnormal and probably permanently in velvet without being shed. The endocrine regulation of antler growth is briefly discussed with reference to antlered does. The need for further examination of the reproductive organs of antlered does is emphasized.

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AGE CRITERIA IN MINK, *MUSTELA VISON*

By R. R. Lechleitner

The desirability of a reliable means of determining the age composition of the harvest of game animals has been indicated by Leopold (1936), and emphasized for furbearers by Yeager (1950), and by Elder (1951). This study was undertaken to investigate certain characters available from the carcasses of mink (*Mustela vison*, Schreber), in order to determine their value as criteria for aging. A series of 370 carcasses of ranch mink of known age was collected and studied. This series consisted of 100 young males, 70 adult males, 100 young females, and 100 adult females. The following characters were investigated; skinned carcass weight, total length, baculum weight and morphology, femur length and morphology, twenty skull measurements characterizing various aspects of cranial development, and the general morphology of the skull.

A sample of 280 carcasses of wild mink was collected from trappers throughout the western portion of Montana during the 1951 trapping season. Where practical, the characters described above were studied on these animals and an attempt made to compare them with those from the ranch animals. The wild mink were all collected within the reported distributional area of *Mustela vison energuemenos* (Hollister, 1913). The sample consisted of 164 or 58.5 per cent males, and 116 or 41.5 per cent females. These figures indicate a significant divergence from the hypothetical 50–50 sex ratio.

Weights and total lengths of skinned carcasses.—The weights and lengths taken proved to be entirely unreliable as age criteria with the ranch animals. The weights and lengths of the males and females tend to be distributed in the same manner, although they are in general smaller for the females. There was only one case of overlap between the weights of the males and females. The lengths of ten males and ten females showed overlap.

The wild mink were preserved in formalin when received and thus no comparison could be made between the skinned carcass weights of these animals and those of the ranch animals.

Bacula.—The baculum has been used with members of the family Mustelidae as an age criterion. Wright (1947, 1950) found that there was no overlap in the weights of bacula from juvenile and adult long-tailed weasels (*Mustela frenata*), and, using known age animals, showed that conformation of the baculum alone was a reliable means of separating immature and mature animals. The changes in conformation were shown to be regulated by the male sex hormone and to occur at the time of increased flow of the hormone at sexual maturity. Elder (1951) has adequately described the morphology of the baculum of the mink and some of the changes which occurred with age from a sample of 242 bacula from ranch animals of known age. The sample of bacula in this study does not reveal any differences in morphology from that described by Elder. The 170 bacula from the ranch mink lend further support to Elder's findings that the bacula from adult animals can be separated from those of the young of the year by means of conformation alone. In the older group the bones are more massive, the shaft more heavy, and the proximal end developed to a greater extent, being more elongated and rugose. The bacula from all adult ranch mink studied have a distinct ridge formed at the point of attachment of the corpus cavernosum. This ridge is lacking on the bacula from the young animals and its presence or absence appears to be a definite criterion for separating the bacula of immature animals from those of animals which have reached sexual maturity.

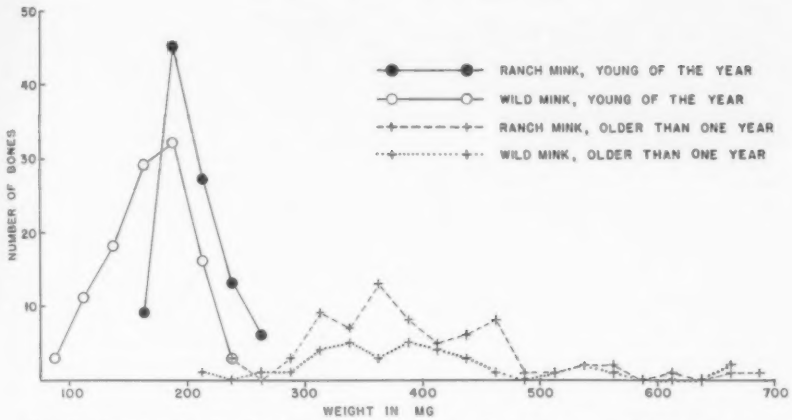

FIG. 1.—Frequency distribution of weights of bacula from 170 ranch mink of known age, and the weights of bacula from 144 wild mink classified as young or old by conformation of the basal end of the baculum.

The bacula from the wild animals are similar in morphology to those from the ranch animals, and like the latter are readily divided into two groups on the basis of conformation of the basal end.

Figure 1 shows a frequency distribution of the weights of the bacula from young and adult ranch mink as well as the weights of bacula from wild mink that have been classified by conformation of the basal end as from young or old animals.

The bacula of the young ranch mink have a mean weight of 203 mgms. and a standard deviation of ±25.4 mgms. The bacula of the old ranch mink have a mean weight of 395 mgms. and a standard deviation of ±90.0 mgms. There is overlap between the means ± two standard deviations for the age groups, indicating that weight alone will not distinguish the age classes in 95 per cent of the cases. The weights of the bacula from the wild mink classified as from young or old animals are distributed in a manner similar to those from the ranch animals. The bacula from the wild mink which were classed as young of the year have a mean weight of 172.0 mgms. and a standard deviation of ±34.2 mgms. The bacula from the wild mink classed as older than one year have a mean weight of 398.1 mgms. and a standard deviation of ±97.0 mgms. Like the baculum weights from the ranch animals there is overlap between the means ± two standard deviations for the two groups of wild mink, indicating that baculum weights will not distinguish the age classes of these animals in 95 per cent of the cases.

When the entire group of 153 wild males, which have the baculum intact enough for classification, is divided into groups representative of age by means of conformation, 119 are classed as young and 34 are classed as adult. The age composition of the males in this sample from the trappers catch is thus 28.5 adults per 100 young.

Femurs.—A series of 180 femurs was collected from ranch mink of known age. This series consisted of 50 from young males, 53 from old males, 33 from young females and 44 from old females. A series of 108 femurs from male wild mink and 90 from female wild mink was collected and examined.

The total length of each femur was measured with a vernier caliper and repeated measurements showed them to be accurate to the nearest .1 mm. These measurements have no use as an age criterion and show slight overlap between the sexes.

The femur of the mink differs but slightly from the femur of the cat (Hymen, 1942) or

the dog (Sisson and Grossman, 1940). The head, trochanteric fossa, two trochanteric processes, the lateral and medial condyles, the condylar fossa, the sesamoid bones and their facets are all relatively well developed in the femur of the mink. The crest of the shaft is poorly developed or absent and the nutritive foramen is small. Although all of the femurs have the epiphyseal groove closed it is found that the femurs are of two types regardless of sex. These two types differ from each other by the development of a small lateral tubercle on the distal end just proximal to the large lateral condyle and the facet of the lateral sesamoid bone. On many of the femurs from young ranch animals the bone at the epiphyseal closure has a spongy appearance. All of the femurs from the old ranch animals have the bone at this area more dense and smooth. It appears that with advancing age there is a tendency of the bone in this area to become more dense and at the same time there is built up a conical elevation in the origin of the gastrocnemius muscle. This elevation is designated in this paper as the lateral supra-sesamoid tubercle. Plate 1 shows the distal ends of two femurs from ranch mink of known age, which illustrate the presence and absence of this tubercle. The femur on the left is from a young male ranch mink and the one on the right is from an adult male ranch mink. Note the lack of a conical elevation on the lateral side just proximal to the large condyles and the porosity of the bone in this area on the femur on the left, whereas on the femur on the right the bone of this area is more dense and smooth and a definite conical elevation is formed.

Table 1 shows the incidence of occurrence of this tubercle for each sex and age class. With the ranch animals of known age, if the presence of this tubercle is used as a means of separating the animals into groups representative of age it is found that two old males are classified as young, all young males are classified correctly, two young females are classified as adults

PLATE I

Distal end of femurs from ranch mink of known age. LEFT: Young male. RIGHT: Adult male. See text for description.

TABLE 1.—*Status of the lateral supra-sesamoid tubercle on femurs from ranch and wild mink*

Age and Sex	Status of the Lateral Supra-Sesamoid Tubercle		
	Total No.	No. with Tubercle	No. without Tubercle
Young ranch males	50	0	50
Old ranch males	53	51	2
Young ranch females	33	2	31
Old ranch females	44	44	0
Young wild males*	84	4	80
Old wild males*	24	22	2
All wild females	90	23	67

* Age determined by baculum conformation.

and all adult females are classified correctly. Had more femurs been collected even greater disparity might have been found between the age groups and the presence or absence of this tubercle.

The femurs from the wild animals appear to be identical in morphology with those from the ranch animals, and like the latter are of two types differing as stated for the ranch animals, by the presence or absence of the lateral supra-sesamoid tubercle. The status of this tubercle in the various age groups of the male wild mink is indicated in Table 1. From these figures it can be seen that if it is assumed that those femurs which have the tubercle came from animals greater than one year old, and those femurs which lack the tubercle came from animals less than one year old, two animals which are of the old age class by baculum conformation are placed in the young age class, and four animals whose bacula show them to be in the young age class are placed in the old age class. By the baculum method, which appears reliable, figures of 84 or 78 per cent young and 24 or 22 per cent old are obtained. By the femur conformation method figures of 82 or 76 per cent young and 26 or 24 per cent adult are obtained.

Since there was no reliable means found with the ranch animals for separating the females into age groups, the femurs from the female wild mink appear in the table as one group. If it is assumed that the status of the lateral supra-sesamoid tubercle can be used to indicate the age composition of the females, it is found that by this means 23 or 25 per cent of the females are older than one year, and 67 or 75 per cent are younger than one year. These figures do not differ significantly, as determined by the chi square method, from those obtained for the males by either the baculum or the femur method.

To determine if there were differences in the femurs of the age groups that might be revealed by x-ray, a series of 40 femurs from ranch animals representing ten from each sex and age group were x-rayed. These plates reveal no noticeable difference between the bones of the groups, and accordingly are not presented here.

Skulls.—In the sample of skulls from ranch mink there are no instances of open sutures. It appears that in the mink, as in the short-tailed weasel (Hill, 1939), and in the European stoat (Deansely, 1935), the sutures close early in life, excluding the possibility of using their closure as a criterion of age during the pelting season. None of the skulls show appreciable tooth wear or the presence of dental caries, although a number of them are from animals 4½ years of age. The rugosity of the brain case and the density of the bone does not show any consistent difference between the age classes and there appears to be no way these characters can be used to separate the young from the mature animals.

As in the ranch mink there are no instances of open sutures on the skulls of wild mink collected during the fall trapping season. A skull from a mink found freshly killed at Bowman Lake in Glacier National Park on August 18, 1952, has the sutures between the two nasals, between the nasals and the maxillaries, between the nasals and the frontals, and

between the frontals and the maxillaries still open; nevertheless, all of the permanent dentition is in place.

Contrary to the findings for the ranch animals, tooth attrition is evident on many of the skulls from wild mink. An attempt to classify *Mustela erminea* into age groups by means of tooth wear has been made by Strogonoff (1937), and it appeared that this criterion should be studied with the mink. Each skull was examined to determine the amount of wear on the upper carnassial teeth. The degree of wear was objectively indicated as none, slight, medium, or heavy. The carnassial teeth were used because they show little damage, whereas, the incisors, canines, and other premolars are often broken or missing, probably as a result of the animals fighting the traps. The skulls were classified as from young or old mink by means of baculum conformation and the results showed that tooth wear is not a reliable means of distinguishing the age classes of wild mink in this sample.

The twenty measurements indicated in Table 2 were taken on each of the skulls. The accuracy of the measurements were determined from repeated measurements of the same character on a series of skulls. None of the measurements could be considered more accurate than is indicated in Table 2.

Measurement number 2, the length along the midline, is the same as that taken by Wright (1953) on the marten, and in that animal is the greatest length of the skull. In the mink this measurement is consistently smaller than the condylobasal length, which is the greatest length of the skull.

Measurement number 17, the calvarion-opisthion, as used here is a modified version of that proposed by Paramonov (1937), who states that the point calvarion should lie "on the anterior anatomical limit of the fossa cerebralis at the corresponding point of the sutura sagittalis." The point calvarion as used here is represented by the central point on a line drawn at right angles to the long axis of the skull and bridging the postorbital constriction.

Measurement number 19, the length of the sagittal crest, has been proposed by Marshall (1951) to distinguish immature from mature marten. The development of the crest in the

TABLE 2.—*Skull measurements used in an analysis of possible age criteria in mink*

Measurement	Accurate to the Nearest:	Reference
1. Condylobasal length	.1 mm	Hall, 1951
2. Length along the midline	.5 mm	Wright, 1953
3. Basal length	.1 mm	Hall, 1946
4. Palatal length	.1 mm	Hall, 1946
5. Length of auditory bullae	.5 mm	Hall, 1946
6. Zygomatic breadth	.1 mm	Hall, 1946
7. Mastoid breadth	.1 mm	Hall, 1946
8. Rostral breath	.1 mm	Grinnell *et al.*, 1937
9. Interorbital breadth	.1 mm	Hall, 1951
10. Breadth of the postorbital processes	.1 mm	Grinnell *et al.*, 1937
11. Breadth of the postorbital constriction	.1 mm	Hollister, 1913
12. Breadth of the tooth row	.1 mm	Paramonov, 1937
13. Height of the skull at the bullae	.1 mm	Hall, 1951
14. Length of the upper molar	.1 mm	Grinnell *et al.*, 1937
15. Length of the tooth row	.5 mm	——
16. Height of the skull posterior to the upper molar	.1 mm	Hall, 1951
17. Calvarion-opisthion	.5 mm	Paramonov, 1937
18. Senectoorbitale-opisthion	.5 mm	Paramonov, 1937
19. Length of the sagital crest	.2 mm	Marshall, 1951
20. Staphylion-postdentale	.5 mm	Paramonov, 1937

mink differs somewhat from its development in the marten (Marshall, 1951), and the stoat (Deansely, 1937). The two parietal ridges do not meet posteriorly to form a sagittal ridge, but meet at some intermediate point before they do in the posterior region. Growth of this single ridge formed by the fusion occurs both posteriorly and anteriorly from this point. Thus the mink may have a sagittal crest formed on the frontals or anterior portion of the parietals, but this single ridge may open posteriorly to form two ridges. In this study any mink skull on which these double ridges fused anywhere along their length to form a distinct sagittal ridge was considered to have a sagittal crest, and the length of the crest was measured from the most anterior point of this fusion to the lambdoidal ridge.

The mean, standard deviation, standard error and the coefficient of variation were calculated for each of the twenty measurements, using standard statistical formulae (Snedecor, 1937). The results of these calculations appear in tabular form in the complete thesis on file at the library of Montana State University, Missoula, Montana.

With the skulls from ranch mink only six of the twenty measurements indicate a significant difference at the 5 per cent level of confidence as the means $\pm$ two standard errors do not overlap. These six measurements include: the zygomatic breadth, the breadth of the postorbital processes, the breadth of the postorbital constriction, the calvarion-opisthion, the sencetoorbitale-opisthion (only in females), and the length of the sagittal crest. All of the measurements exhibit overlap between the means $\pm$ one standard deviation for the age groups, indicating that age cannot be distinguished in 66 per cent of the cases by using any of these characters alone.

Nine of the twenty measurements taken on the skulls of the male wild mink classified as from young or old animals by conformation of the baculum show a significant difference between the means of the age classes. These nine measurements include: the zygomatic breadth, mastoid breadth, rostral breadth, interorbital breadth, the breadth of the postorbital processes, the breadth of the postorbital constriction, the breadth of the tooth rows, the height at the posterior border of the upper molar, and the length of the sagittal crest. As in the ranch mink, all of the measurements taken on the skulls of the male wild mink exhibit overlap between the means $\pm$ two standard deviations for the age classes.

The sagittal crest is well developed in the ranch mink, especially the males. All of the skulls from male ranch mink have a distinct sagittal crest. The females appear in general to develop the crest at a later date and it does not reach the proportion in females that it does in many males. The skulls from young ranch females show that 54 of 100 do not possess a crest, while it is present on the skulls of all adult females.

The sagittal crest is less well developed on the skulls of male wild mink than it is on the skulls of male ranch mink. Eleven of the skulls from male wild mink classed as young animals do not possess a sagittal crest, whereas, it is present on the skulls of all ranch males. The crest is not present on 29 of 86 skulls from wild female mink.

It appears from this sample that any mink which does not have a sagittal crest may be considered as less than one year of age. If a sagittal crest is present the animal may be in either age class, and the measurement of the crest does not furnish a means of distinguishing its age.

Because the breadth of the postorbital processes appeared to be increasing at the time the breadth of the postorbital constriction was decreasing, the difference between these measurements for each skull was investigated as a means of separating the age classes. This method did not give a separation at the level of confidence desired.

Jurgerson (1933) and Paramonov (1937) expressed the opinion that because of the findings of Hensel (1881) skull measurements should be converted to a percentage of the overall length of the skull if they are to be used as age criteria. The reliability of this method was investigated with the measurements taken. All measurements were converted to a percentage of the condylobasal length for a series of ten animals within each age and sex group. There were considerable overlaps between the age groups with these converted measurements and the investigation was carried no further.

Although none of the skull measurements when considered alone had shown use as an

age criterion, the possibility that some of these measurements in combination may have such a use was investigated. A system was set up whereby each skull was considered individually with reference to the following measurements: the zygomatic breadth, the breadth of the postorbital processes, the breadth of the postorbital constriction, the length of the sagittal crest, the calvarion-opisthion, and the difference between the breadths of the postorbital constriction and the postorbital processes. If a particular skull measurement was found to lie within the range of overlap for the means ± two standard deviations for the measurement for the age classes, the animal was considered according to this measurement to have the possibility of being either young or old. If the measurement was found to lie outside this overlap, the animal was classified as young or old. This system showed some improvement over using the measurements separately, but it was still impossible to classify many of the skulls. After this system was tried on small groups representing each sex and age class it was dropped.

SUMMARY

A series of 370 carcasses of ranch mink of known age was studied to determine if there were any characters that would distinguish the age classes. The following characters were studied: skinned carcass weight, total length, baculum weight and morphology, femur length and morphology, twenty skull measurements characterizing various aspects of cranial development, and the general morphology of the skull.

A sample of 280 carcasses of wild mink, consisting of 164 males and 116 females was studied and where practical compared with the ranch mink for these characters.

Only the baculum morphology is reliable in all cases for determining age classes.

The baculum weights appear reliable for age determination in 66 per cent of the cases but not for 95 per cent of the cases.

The femurs of the mink are of two types which differ by the presence or absence of a small process, the lateral supra-sesamoid tubercle. This tubercle occurs most often on the femurs from the old ranch animals and appears to give a fairly reliable means of distinguishing the age classes.

Using the baculum conformation method of age class determination for the males and the femur conformation method for the females, there are 28.5 adult males for every 100 young males, and 32.8 adult females for every 100 young females in the sample of wild animals. This indicates that the age classes in the two sexes may be represented in approximately equal numbers.

The skull measurements are unreliable either individually or in combinations for distinguishing the age classes in even 66 per cent of the cases. The development of the sagittal crest in the mink differs somewhat from the reported development of this crest in the marten and the weasel. No instances of open sutures, dental attrition or dental caries were found on the skulls of the ranch mink. The skulls of the wild mink are quite similar to those of the ranch mink, but do show dental attrition. The degrees of attrition were objectively measured and found to have no use as an age criterion.

It is recommended that the femurs be included when saving materials from mink carcasses for age composition studies. A comparison should be made be-

tween the age classes of the males as determined by the conformation of the femurs and the age classes of the males as determined by the conformation of the bacula. In this way the reliability of the femur conformation as an age criterion may be more definitely established.

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RED FOX WEIGHTS AND REPRODUCTION IN TIPPECANOE COUNTY, INDIANA

By Roger A. Hoffman and Charles M. Kirkpatrick

A seasonal habit characteristic of red foxes—that of sleeping or bedding in the open during daylight hours, particularly in sunny stubble, weeds or briar patches—makes the species unusually vulnerable to hunters from December to March in Indiana. Various fox hunting methods take advantage of this habit, and as a result of fox drives, tracking on newly-fallen snow, and the use of airplanes in spotting foxes for ground parties, heavy kills are made during December, January, and February. As shown by statewide county fox bounty records for the period 1875–1948 (Haller, 1950) the monthly total of foxes bountied in Indiana was greatest for May (accounted for by pups taken at dens) followed by January, December, and February in that order. These winter months probably encompass the main period of estrus or breeding in the latitude of Tippecanoe County. For Indiana, Lyon (1936) states that "mating occurs in late winter" and for Boone County, Iowa, Scott (1943) gives the estrus period as sometime during late December and early January.

During the winter of 1947–48 it occurred to one of us (CMK) that considerable data on body and organ weights and reproduction in Indiana foxes were available almost daily from local bounty stations. At that time little was known about reproduction in wild foxes, as noted by Sheldon (1949), or about weights. Since it was felt that any considerable series of reliable observations would add to the knowledge of this important and widely distributed species, arrangements were made to examine whatever foxes were presented for bounty in Tippecanoe County during the winter months of 1947–48 and early 1949. This report considers only the red fox (*Vulpes fulva*).

Materials and methods.—A total of 52 male and 52 female red foxes was examined. For various reasons not all foxes bountied were handled so the data presented here are from only a sample of the total kill during the period.

The entire carcass was weighed to the nearest five grams on a direct reading dial type platform scale with a capacity of 4500 grams. Specimens in excess of this capacity were weighed on a straight spring balance to the nearest quarter of a pound and the avoirdupois weight was converted to the metric for computing the averages. The body weights were taken without allowing for fresh or frozen condition, loss of blood, burrs in coat, stomach contents, etc.

The adrenal and thyroid glands and ovaries were weighed to the nearest milligram and the testes to the nearest tenth of a gram. The testes from suitable specimens were studied microscopically to determine the stage of spermatogenesis.

The uteri of the females were examined and gross observations on breeding condition were made including counts of uterine enlargements and fetuses. During February of each year some of the fetuses were removed for crown-rump measurements.

TABLE 1.—*Body and organ weights in grams of Indiana red foxes in winter*

	Males			Females		
	Number	Range	Mean ± Std. Error	Number	Range	Mean ± Std. Error
Body	47	3980–6090	5253 ± 77.6	52	3360–5680	4213 ± 73.6
Gonad	23	2.9–15.5	8.62 ± .542	17	.315–2.430	1.165 ± .159
Adrenal	20	.273–1.455	.577 ± .057	16	.270–.600	.447 ± .019
Thyroid	20	.162–.620	.413 ± .050	14	.154–.510	.351 ± .002

During the second winter no organ weights were taken but observations on reproduction in the females were continued.

A statistical analysis was made of all series of weights with arithmetic means and standard errors computed for each variable. Coefficients of correlation were computed for all the weight interrelationships.

RESULTS AND DISCUSSION

Weights.—A summary of the body and organ weights is given in Table 1. For comparison with other published figures, the mean body weights and ranges are converted here to avoirdupois. Thus the mean body weight of males was 11.57 pounds with a range of 8.4–13.4 pounds. For females the mean body weight was 9.28 pounds with a range of 7.4–12.5 pounds. Lyon (1936) gives the weights as 8–15 pounds and Hamilton (1943) as 8–12 pounds. Most authors are in agreement that on the average females are slightly smaller than males. The stomach contents of 13 foxes averaged 102 grams (3.6 oz.). Little or no visceral fat was noted in animals autopsied.

Thirty-one of the 52 females weighed were pregnant as shown by uterine enlargements or the presence of fetuses up to 55 mm. long. In some cases these uterine young and their enveloping membranes and fluids undoubtedly added measureably to the total weight of the vixens. A case in point is the heaviest female (No. 62) bearing 13 fetuses which were far from full term. Presumably the large number of young contributed to this animal's outstanding weight of 12.5 pounds and the total weight of female and unborn litter would have increased markedly as fetal growth continued to term. According to Sheldon (1949) fox pups at birth average about 100 grams. A similar sample of nonpregnant adult females might be expected to result in an average body weight somewhat less than that given above.

For two female red foxes, Crile (1941) gives thyroid and adrenal weights that average .275 and .474 grams respectively. Our mean weights for these organs from a larger series indicate that female thyroids average heavier and adrenals lighter than Crile's averages. In 80 per cent of the cases when both organs were weighed, i.e., adrenals and thyroids, adrenal weights were heavier.

Significant correlations exist between body weight and gonad weight in both sexes (Table 2), but not in the other body weight to organ weight relationships.

Spermatogenesis.—Seven of 17 males studied were producing fully formed sperm and 14 were producing either sperm or spermatids. This clearly indicates

TABLE 2.—*Body weight to gonad weight correlation in Indiana red foxes in winter*

Relationship	No.	Mean ± Std. Error	Standard Deviation	Correlation Coefficient (r)	Regression Curve Equation
Testis wt. (y).....	19	8.95 ± .49	$\sigma y = 2.16$	r = .565	y = 0.00229x-2.47
Body wt. (x).....		4994 ± 122.4	$\sigma x = 533.58$	±.156*	
Ovary wt. (y).....	17	1.161 ± .233	$\sigma y = .961$	r = .610	y = 0.00105x-3.17
Body wt. (x).....		4100 ± 134.6	$\sigma x = 555.0$	±.146*	

* Significant.

that active spermatogenesis does occur between December 20 and February 10. The stage of spermatogenesis did not seem to be correlated either with testis weight or body weight and thus, inferentially, with age or condition.

Apparently observations on spermatogenesis in *Vulpes fulva* have been confined to fur farm silver foxes. The present data are limited in time span but nothing suggests that the wild red fox males differ from ranch foxes which produce sperm from late November to the middle of April (Bishop, 1942).

Reproduction in vixens.—Of 52 vixens examined from December 17 to February 24 during two winters, 31 were pregnant and four were either in or near estrus (Table 3). On the basis of macroscopic examination, 17 of the females from December 17 to February 21 were in the anestrus condition. During the first winter, five of these were seen before the first pregnancy noted on January 2, and the second winter, five were seen before the first pregnancy recorded February 2. It is not apparent why first pregnancies were noted a month later the second year than the first. More females collected earlier in either of the years might have shown either no lag or more advanced pregnancy dates. Yearling ranch foxes breed later than adults (Pearson and Bassett, 1946), so presumably the higher the percentage of juveniles in the population, the later will be the average breeding date (Sheldon, 1949). However, this should not affect the early extremes.

The season of estrus in red fox vixens and mating probably vary with latitude (Sheldon, 1949). By using a 53 day gestation period it is interpolated from Lyon (1936) that Indiana foxes breed near the end of February. For New York red foxes, Sheldon (1949) states that they "breed from mid-December to late March . . . ", apparently basing the early period upon December uterine turgidity as an indication of estrus. In Indiana some red fox matings take place in December as shown by gravid female No. 26 collected on January 2, and probably Nos. 32 and 36 collected on January 10 and 12 respectively. The latest date for an estrus or near estrus female (No. 109) was February 14. Thus the minimum extent of estrus in Indiana red fox vixens is established from some time in December to mid-February.

Litter size.—Lyon (1936) gives the litter size as 4–9 pups which is similar to the figures of other writers. The average of 210 Michigan red fox litters removed from dens was 4.92 (Switzenberg, 1950). Counts of young foxes seen at or taken from dens permit inaccuracy because of pups overlooked, post-natal mortality, or communal denning. The counting of fetuses and placental scars offers a more accurate means of assessing each vixen's productivity, but such counts are

TABLE 3.—*Post mortem observations on reproduction in Indiana red fox vixens*

Fox No.	Date Collected	Body Wt. (grams)	Ovary Wt. (grams)	Uterine Condition
			First Winter	
26	1- 2-48	4310	.860	7 enlargements
32	1-10-48	3880	.650	7 fetuses (4-3)
36	1-12-48	4540	1.401	9 fetuses (5-4)
46	1-28-48	3695	1.620	horn diameter 5 mm.; vascular
47	2- 4-48	4310	1.213	horn diameter 5 mm.; vascular
50	2- 7-48	4540	2.320	7 enlargements
51	2-10-48	3860		8 fetuses (4-4); 11 mm.
52	2-10-48	4540		8 fetuses (4-4); 17 mm.
55	2-10-48	4540		7 fetuses (4-3); 20 mm.
56	2-10-48	3630	1.180	4 fetuses (2-2)
58	2-10-48	3635		5 fetuses (2-3)
60	2-10-48	3860		7 fetuses (4-3); 9 mm.
61	2-10-48	4440	1.722	6 fetuses (3-3); 25 mm.
63	2-14-48	3520	1.500	5 fetuses (3-2); 11 mm.
62	2-16-48	5680	2.430	13 fetuses (7-6); 55 mm.
66	2-24-48	4215	1.975	5 fetuses (2-3)
			Second Winter	
83	2- 2-49	4090		8 enlargements (early)
84	2- 2-49	5220		8 enlargements (early)
88	2- 3-49	5000		5 enlargements (early)
91	2- 3-49	4310		horns enlarged; vascular
92	2- 3-49	5100		6 enlargements
98	2- 5-49	3980		7 enlargements (4-3)
100	2- 7-49	4650		7 enlargements (4-3)
101	2- 7-49	3740		7 enlargements (3-4)
102	2- 7-49	5000		5 fetuses (3-2); 15 mm.
104	2- 7-49	4310		6 enlargements (3-3)
108	2-10-49	4310		6 enlargements (3-3)
109	2-14-49	4085		horns enlarged
112	2-14-49	4310		9 enlargements (4-5); early
115	2-14-49	4760		5 fetuses (3-2); 30 mm.
116	2-14-49	4540		6 enlargements (3-3)
118	2-14-49			pregnant uterus removed by hunter
121	2-19-49	4200		8 fetuses (5-3); 27 mm.
123	2-21-49	4310		6 fetuses (3-3); 20 mm.
127	2-22-49	4540		7 fetuses (3-4); 42 mm.

nothing more than what meets the eye. The number of uterine young is not necessarily the number that will be born alive, and the placental scars give only the number borne. Thus the litter size based upon pups at the den is not by any means the same as that based upon uterine counts of fetuses, enlargements, or scars. By using the latter method different investigators report the average red fox litter size to be 5.3 and 5.1 (Sheldon, 1949; Richards and Hine, 1953).

In the present study of 30 gravid uteri examined, the number of enlargements and fetuses ranged 4–13 with the average of 6.8 ± .338 potential young per female. The evidences of pregnancy included thick-walled uterine swellings of

15–20 mm. in diameter to fetuses 55 mm. in crown-rump length. An observation of interest was that in 24 females the implantations of even numbered litters were distributed evenly between horns with the exception of No. 121 where a 5–3 distribution was found; in odd-numbered litters, one horn, usually the right, contained a single extra site or fetus.

The remarkable number of 13 fetuses found in No. 62 bears comment. This observation seems to be a record of the largest number of young a wild red fox can have assuming that normal, full-term birth would have followed. In our series, the body, adrenal, and ovarian weights of this vixen were the heaviest recorded. The fetuses were distributed seven in the right uterine horn and six in the left. They were found in only 11 fetal capsules, nine of which contained a single fetus and two of which contained "twin" fetuses, one each of the latter being in each horn. All the fetuses were normal in appearance with no indications of resorption or retardation, being uniformly about 55 mm. in crown-rump length.

In the literature on American red foxes, no report has come to our attention of a vixen known to have borne more than 11 young. Nine is the maximum recorded in a large series of uterine counts by Sheldon (1949). Switzenberg (1950) reports litters of 11, 14, and 15, but communal denning of more than one family was suspected in the larger litters. Sheldon (1950) found that two litters in one den was not uncommon. A large number of fetuses, as explained above, is not positive evidence of the number of pups born or living after birth. Apparently nothing is known about post-natal mortality in wild red foxes.

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SUMMARY

During the winters of 1947–48 and 1948–49, a total of 52 each of male and female red foxes (*Vulpes fulva*) were collected from the Tippecanoe County, Indiana, bounty station for the purpose of obtaining weights and observing the reproductive condition.

Mean weights with ranges and standard errors are presented for body, gonad, adrenal, and thyroid. Correlation coefficients for all weight interrelationships were computed with only the body weight to gonad weight relationship showing significance.

Microscopic examination of testis sections from 17 males collected from December 20 to February 10 showed that 7 were producing sperm with the most advanced stages ranging from primary spermatocytes to spermatids in other individuals.

Evidence is presented that the minimum extent of estrus in Indiana vixens is from sometime in December until mid-February.

Pregnancy in 31 of 52 vixens examined from December 17 to February 24 during two winters was determined by inspection of uteri. On the basis of enlargements or fetuses the average number of uterine young was 6.8 with a range of 4–13.

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REPRODUCTION IN THE HOUSE MOUSE, *MUS MUSCULUS* L., IN MISSISSIPPI

BY WILLIAM W. SMITH

During the period from July 1, 1949 to June 30, 1950, a survey of house mice (*Mus musculus*) was conducted by the Mississippi State Board of Health and the Communicable Disease Center of the Public Health Service as a part of the murine typhus control program of the State of Mississippi. In addition to determination of the incidence of typhus in the mice and the type, abundance, and distribution of the ectoparasites, it was believed that valuable information might be obtained to indicate the presence or absence of seasonal breeding cycles, and the effects of certain environmental factors on the reproductive activity of the mice.

Materials and methods.—Live traps of the cage type used in a rickettsialpox survey in New York City (Horn, 1949) were used, the traps being set in the late afternoon of one or two days each week. Mice were collected in the early morning and transported to the laboratory in the traps, anaesthetized, and killed by cardiac puncture. After the ectoparasites were removed, the mice were measured from the tip of the nose to the base of the tail, and the sex was determined. Females were dissected so that the uterine horns might be examined for the presence of swellings which indicate the presence of developing embryos. This method revealed about 18/22 of the true pregnancies of Norway rats as calculated by Davis (1951*a*). It is believed that about 14/19 of the true preg-

FIG. 1

nancies of house mice may be detected by such examinations. Measurements of length and pregnancy data were correlated to indicate the maturity of female mice.

Trapping was conducted in 45 localities in 23 counties of the State as shown on the accompanying map (Fig. 1). Four types of indoor habitats, 1) food-handling, 2) other business, 3) farm building, and 4) residence, were sampled.

SURVEY DATA AND DISCUSSION

Effects of habitats on the trap yields of mice.—The findings derived from the methods described are recorded in Tables 1 and 2. In Table 1, the higher number of food-handling establishments trapped (429) is indicative of heavier mouse infestations since traps were set only at stations which gave promise of being productive. Farm buildings were rather unproductive due to the presence of abundant food supply, the presence of predatory animals and rats which upset the traps, and to other factors. Statistical analysis of the average yields per

TABLE 1.—*Number and sex of house mice trapped in indoor habitats in Mississippi; July 1, 1949–June 30, 1950*

Habitat	Total No. Stations Trapped	Av. No. Mice per Station	No. Males	No. Females
FHB*	429	2.40 ± .10**	527	506
OB	98	2.37 ± .24	103	127
F	21	1.57 ± .30	15	18
R	162	2.26 ± .15	186	174
Totals	710	2.33 ± .07	831	825

*FHB = Food-handling establishments.
OB = Other business establishment.
F = Farm building.
R = Residence.
** Standard error.

TABLE 2.—*House mouse maturity, pregnancy, and litter size in indoor habitats in Mississippi; July 1, 1949–June 30, 1950*

Habitat	No. Mature Females	Pregnant Females				
		Total Number	%*	No. in Which Embryos Counted	Embryos	Ave. No. Embryos per Litter
FHB	463	219	47.3	174	866	5.0 ± .12**
OB	120	56	46.7	43	184	4.3 ± .19
F	16	8	50.0	6	22	3.7 ± .17
R	166	75	45.2	69	335	4.9 ± .17
Totals	765	358	46.8	292	1407	4.8 ± .09

* $\% = \frac{\text{No. Pregnant Mice}}{\text{No. Mature Females}}$.
** Standard error.

station does not indicate significant differences in those for any of the types of habitats sampled.

Sex ratio with reference to habitat and season of year.—The totals of male and female mice trapped (831 males, 825 females) indicate a 1:1 sex ratio as found for laboratory mice by Snell *et al.* (1941) and by Davis (1951*a*) for Norway rats. More females than males were caught in business establishments other than food-handling places and on farms, while larger numbers of males were captured in food-handling establishments and residences. However, chi-square tests indicate that the numbers of males and females in each type of habitat do not differ from a 1:1 ratio ($P < .05$).

Statistical treatment of the monthly survey data totals shown in Table 3 discloses the fact that a preponderance of female mice (192 females, 160 males) were caught during the months of July, August, and September (chi-square = 2.9; $P = .08$). During the next three months, males predominated (229 males,

TABLE 3.—*House mouse sex, maturity, pregnancy, and litter size in Mississippi, by months; July 1, 1949–June 30, 1950*

Month	No. Males	No. Females	No. Mature Females	% Pregnant	No. Mice in Which Embryos Counted	Av. No. Embryos/Mouse
July	20	29	29	27.6	0	
Aug.	43	52	49	49.5	10	5.1 ± 0.57*
Sept.	97	111	99	56.6	29	4.8 ± 0.24
Oct.	87	78	72	40.3	23	4.4 ± 0.33
Nov.	67	47	45	57.8	25	4.4 ± 0.21
Dec.	75	63	53	32.1	17	4.5 ± 0.47
Jan.	47	48	47	36.2	17	4.5 ± 0.44
Feb.	61	62	57	38.6	22	4.8 ± 0.37
Mar.	62	77	72	30.6	22	4.4 ± 0.44
Apr.	102	78	73	49.3	36	4.3 ± 0.28
May	105	118	113	58.4	66	5.1 ± 0.19
June	65	62	56	44.7	25	5.1 ± 0.31
Totals	831	825	765	46.8	292	4.8 ± 0.09

* Standard Error.

188 females) (chi-square = 4.04; $P < .05$). In January, February, and March, the 1:1 ratio was maintained, the difference between males and females in March (62 males, 77 females) failing to reach significance level (chi-square 1.6; $P = .20$). The month of April showed more males than females (102 males, 78 females) probably as a result of increased breeding activity. The following month was characterized by a reversal which showed 118 females and 105 males taken. It was noted that for two of the three months in which the pregnancy rate was above 50 per cent, the majority of mice caught were females. Davis (1951*a*) caught a higher percentage of female Norway rats (53 per cent) than males during the highest reproductive period. In June, the pregnancy rate declined and a 1:1 ratio was resumed.

Sexual maturity of house mice as related to length and habitat.—As previously indicated, length measurements of female mice were compared with evidence of pregnancy to indicate maturity. This method was chosen as more satisfactory in field practice than the use of weight or other attributes which required more complicated procedures or apparatus. Female mice less than 2½ inches in length were not found pregnant except in the north central region where an occasional specimen only two inches in length was pregnant. A body length of 2½ inches was used as a criterion of maturity in all the State except the north central region where two-inch specimens were considered mature. Based on these limits, 92.7 per cent (765) of all females trapped were mature.

Peaks of pregnancy rates (above 50 per cent) were followed one month later by higher percentages of immature mice in the traps, except in September. This exception might be due to the development of the young mice to foraging age within the month, the pregnant females having been caught early in the month.

Pregnancy in relation to type of habitat and locality.—As shown in Table 2,

pregnancy rates in each of the four types of habitats were remarkably similar and no significant differences could be demonstrated by statistical tests. Davis (1951*b*) found no difference in the crude incidences of pregnancy in Norway rats taken from city and farm habitats.

A study of pregnancy rates by regions of the State indicated that the highest rate occurred in the north central region (61.2 per cent) composed of Benton, Marshall, Lafayette, and Yalobusha counties, and the lowest rate (41.9 per cent) in the northwest central region composed of Leflore, Carroll, Montgomery, Sunflower, and Holmes counties. Conversely, the lowest average number of embryos per litter (4.3) occurred in the north central region and the highest (5.6) in the northwest central region.

Pregnancy in relation to season of the year and average temperatures.—Table 3 shows pregnancy rates for each month of the survey year. It may be seen that the highest rates occurred during the months of August, September, October, and November, and again in April, May, and June. These maxima are statistically substantiated when compared with the rates for the months of December, January, February, and March. They are similar to the findings that house mice in Baltimore, Maryland, have breeding maxima in the fall and spring seasons (Brown, 1953). It is to be noted, however, that there was no complete cessation of breeding during the winter.

When monthly pregnancy rates are compared with average monthly temperatures for the State, four phases of breeding activity are evident. The first phase is that of July when a low percentage of pregnancy accompanied very high average temperature (81.4° F.). The second phase was one of high reproductive rates accompanied by a mean temperature of about 70° F. for the months of August, September, October, and November. Low rates accompanied by a low mean temperature of near 55° F. characterized the third phase in December, January, February, and March. The fourth phase was one of relatively high mean temperature (71° F.) and high reproductive activity. It was concluded that mean temperatures in the neighborhood of 70° F. were most favorable for greatest reproductive activity during this survey.

Litter size as related to type of habitat.—Table 2 indicates that mice from food-handling establishments and residences had more embryos per litter (5.0 and 4.9 respectively) than those from other businesses and farm buildings (4.3 and 3.7 respectively). It is probable that the availability and nutritional quality of the food supplies of the mice in these different types of habitats affected the number of young. In a study of rat populations in cities and on farms, Davis (1951*b*) found that city rats had more embryos per litter than farm rats. It should be remembered however, that resorption and heavy post-partum mortality may affect considerably the numbers of mice and rats produced under certain unfavorable conditions.

The final figure of 4.8 embryos per litter agrees closely with the estimate of Garlough and Spencer (1944) of 5 per litter, and with that of Storer (1948) of 5 or 6 per litter. It is somewhat lower than the estimate of Laurie (1946) of 6 to 8 per litter.

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SUMMARY

In connection with the murine typhus control program of Mississippi, house mice were live-trapped during a one-year period from four types of indoor habitats in 45 localities widely distributed in the State. Mice were separated according to sex, were measured, and were dissected to determine pregnancy rates and litter size.

Food-handling establishments were indicated to be more heavily infested than the other types of indoor habitats. Trap yields were largest in food-handling establishments and were least productive in farm buildings. Statistical testing of totals of males and females caught in the various habitats failed to show divergence from a 1:1 sex ratio. This ratio was not affected by the locality from which the mice were taken. However, more females than males were caught in the traps when pregnancy rates were at their highest peaks in the spring and fall months. Males predominated in the traps during the months of October, November, and December.

Sexual maturity of female mice was indicated by a minimum body length of 2½ inches in all parts of the State except the north central part where a few mice only two inches in length were found pregnant.

Periods of highest reproductive activity occurred in the periods from August through November, and April through June. Different types of habitats did not appear to influence the pregnancy rates. The region (north central) which had the highest pregnancy rate (61.2 per cent) had the lowest average number of embryos per litter (4.3), and the region (northwest central) which had the lowest pregnancy rate (41.9 per cent) had the highest number of embryos (5.6) per litter. Periods of high reproductivity were accompanied by mean period temperatures of near 70° F., while relatively higher temperatures (81.4° F.), or lower ones (55° F.), were accompanied by lower rates of pregnancy.

The litters of mice taken from food-handling establishments and from residences were larger than those taken from farm buildings and other business places. No significant differences could be shown in monthly litter means. The average number of young per litter as determined by counting embryos was 4.8.

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RODENT HABITAT PREFERENCES ON FOOTHILL PASTURES IN CALIFORNIA

BY JAY C. QUAST

The San Joaquin Experimental Range is in an area of granite outcrops, blue oak, (*Quercus douglasii* H. and A.), digger pine, (*Pinus sabiniana* Dougl.), and wedgeleaf ceanothus (*Ceanothus cuneatus* (Hook.) Nutt.) located in the Sierra Nevada foothills 25 miles northeast of Madera, California. Some of the pastures of this area have been subjected to different cattle grazing intensities for periods of years with the result that grass, forb, and shrub growth differs on them. In the fall and spring of 1949–1950, while working under Dr. Walter E. Howard of the University of California at Davis, the author attempted to assess the differences in the small rodent habitats in these areas of different cattle utilization. The small mammals considered were: Gilbert white-footed mouse, *Peromyscus truei gilberti* (Allen); Boyle white-footed mouse, *Peromyscus boylii boylii* (Baird); Gambel white-footed mouse, *Peromyscus maniculatus gambelii* (Baird); and the Tulare kangaroo rat, *Dipodomys heermanni tularensis* (Merriam).

Four plots were chosen, each of four acres, and were live-trapped for seven or eight day periods. The plots differed considerably in physical and cover characteristics, and will be referred to as the heavily grazed swale plot, ungrazed swale plot, ungrazed ceanothus plot, and moderately grazed ceanothus plot (Table 1). Each was trapped with 128 live traps set at intersections of a 30-foot grid. The first four nights a center square of approximately two acres was trapped, the traps then being moved from the center square to its peripheral region and placed at 30-foot intervals as before and set for three, or sometimes four, nights.

All animals taken in each night trapping period were marked by toe clipping and released the next morning. Records were kept of each capture, listing the position of the trap in the grid, grass condition at trap site, and distance from the

TABLE 1.—*Composition of four plots studied for rodent habitat preferences*

Plots	Number of Trees	Percentage of Total Area			
		Ceanothus	Rocks under Canopy	Open Rocks	Grass
Heavily grazed swale plot	26	1.0	.4	4.3	94.3
Ungrazed swale plot	12	5.2	2.2	6.2	86.4
Ungrazed ceanothus plot	19	27.0	.6	4.0	68.4
Moderately grazed ceanothus plot	6	22.1	.2	.6	77.1

TABLE 2.—*Total animal captures on four plots*

Plot	Total Captures	Number Marked	Per Cent of Total Marked on Plot
Heavily grazed swale plot			
Peromyscus truei	23	7	31.8
Peromyscus boylii	14	4	18.2
Peromyscus maniculatus	41	6	27.3
Dipodomys heermanni	12	5	22.7
Ungrazed swale plot			
Peromyscus truei	25	10	40.0
Peromyscus boylii	30	8	32.0
Peromyscus maniculatus	—	—	—
Dipodomys heermanni	10	7	28.0
Ungrazed ceanothus plot			
Peromyscus truei	67	18	54.5
Peromyscus boylii	8	3	9.1
Peromyscus maniculatus	—	—	—
Dipodomys heermanni	25	12	36.4
Moderately grazed ceanothus plot			
Peromyscus truei	20	6	46.2
Peromyscus boylii	5	2	15.4
Peromyscus maniculatus	8	4	30.8
Dipodomys heermanni	1	1	7.7

various kinds of cover. Each area was mapped for rocks, bushes, and trees and the position of each trap was located on this map by means of tracing-paper layovers. By this means the position and movements of each animal within the four acres was determined. Table 2 presents a summary of captures on the plots.

Heavily grazed swale plot.—This plot was located in a pasture that had been very heavily grazed for the previous 16 years. It contained a southern portion of open swale with scattered blue oaks and rock outcrops, and a smaller northern portion of rock outcrops with a sky-cover of digger pine and interior live oak. Grass and forb growth was very low and no standing litter was present in the swale.

All captures of *P. truei* were made in the rocky and tree-canopied portion of the plot although captures were frequent at distances of more than 10 feet from rocks and tree canopies. None was caught in open swale. Captures of *P. boylii* indicated a definite association of this species with rock outcrops, all captures being made adjacent to rocks or cover that was continuous with the rocks.

All but one of the forty-one captures of *P. maniculatus* were made in open swale and rocky areas away from interior live oak and digger pine canopies. Whether this was due to a specific preference for open swale or preemption of rock sites with woody canopies by the other two species of *Peromyscus* was not determined.

Captures of *D. heermanni* corresponded closely to those of *P. maniculatus* in respect to habitat. When released, kangaroo rats usually ran to holes in open terrain. They avoided the digger pine and interior live oak areas and showed no association with boulder outcrops. Homesites were holes in open, sloping terrain and rocky soil, the former seeming to be preferred.

In summary, the largest portion of the heavily grazed swale plot was open swale characterized by lack of litter, very low herbaceous vegetation and little woody cover. In this portion of the plot, the catch was predominantly *P. maniculatus* and *D. heermanni*. The north end of the plot, an area of large digger pines, numerous interior live oaks and rock outcrops, produced *P. truei* and *P. boylii*. Both of the latter species were associated with the boulder outcrops and woody canopies but *P. boylii* appeared to have its home range more closely confined to boulder outcrops and woody cover than *P. truei*.

Ungrazed swale plot.—This was situated in an area of the Experimental Range that had been protected from cattle grazing and fire for the previous 16 years. It was chosen because it resembled the heavily grazed swale plot in all features except cattle utilization.

The terrain of this plot was steeper than that of the heavily grazed swale plot and was crossed by a small seasonal stream that contained running water until May. Large rock outcrops were present, these usually being partly covered by the canopies of interior live oak. A small area of ceanothus was included in one corner of the plot. The swale contained abundant gopher workings and had large amounts of standing dried stalks of tarweed and heavy grass litter at the time of trapping (February 6 to 13). The ground was soft and spongy (in contrast with the first plot where it was packed hard). Under some ceanothus and blue oaks, ripgut grass grew densely.

P. truei was most frequently captured in the vicinity of ceanothus bushes; of those captures away from ceanothus bushes, captures near boulders were most frequently recorded. Plotting the captures on a habitat map showed the activities of this species to be associated with and practically restricted to areas of ceanothus. Rock outcrops were used infrequently.

Over three-fourths of the captures of *P. boylii* were made within 10 feet of rocks. Remaining captures were within 10 feet of ceanothus with the exception of but one made in open swale. The dense grass and litter of the swale appeared to have little restricting influence on movements of this species since captures

were frequently made on isolated rock outcrops over 100 feet from those on which a previous night's capture of the same individual had been made. When captures of *P. boylii* and *P. truei* were plotted on a habitat map it was found that areas occupied by the two species were distinct and overlapped only in one instance where a boulder outcrop occurred near ceanothus bushes.

P. maniculatus was not caught.

Only seven *D. heermanni* were marked and accounted for a total of ten captures. Six of these were under ceanothus; one was within 10 feet of rocks. When the sites of capture were plotted on the habitat map little information was gained other than complete absence of trap records for the densely vegetated swale.

The swale area in the center of the plot was free of overhead canopy but had a thick layer of herbaceous material with no bare soil visible. Trap records were lacking for all four species here. Whether this was due to poor drainage in the area, standing litter interfering with forage and escape, competition with pocket gophers for refuge sites, or other causes was not determined. *D. heermanni* was caught in a section of the swale higher on the hillside and near ceanothus. It was clear that *P. boylii* preferred rocky areas and *P. truei*, brushy areas. All parts of the plot were evidently unfavorable to *P. maniculatus*.

Ungrazed ceanothus plot.—This bordered the ungrazed swale plot on its uphill side and was the next area to be trapped. Drainage was considerably better than in the neighboring swale and at its center the plot contained a belt of ceanothus bushes occupying about one-third of the area. Usually the ceanothus was open, but in a few places it formed a dense growth that was nearly impassable. Few rocky areas were present and grass was generally absent under the denser brush. Under the more open ceanothus, grass cover varied from none to dense, presumably depending upon soil quality and wildlife activity adjacent to the bushes. In general, grass and litter was shorter and less dense than in the swale plot trapped previously.

A large number of *P. truei* was captured, over three-fourths being within 10 feet of ceanothus cover. Plottings of these captures on a habitat map indicated that the mice crossed open areas but that foraging activity was greatly diminished when 10 feet or more from ceanothus canopies. Captures of this species varied inversely to the square of the distance from ceanothus cover and also became less frequent as the brush became less dense.

P. maniculatus was not captured. Only eight captures of *P. boylii* were made, four being near rock outcrops and four away from rocks and under ceanothus.

D. heermanni was the second most common animal marked and 72 per cent of the captures were within 20 feet of ceanothus canopies. The most favored ceanothus bushes were those in poor soil areas that lacked high or dense grass. When released from traps, individuals of this species commonly chose escape routes under bushes that led to burrows there or in open ground nearby. Plots of the captures on a habitat map were concentrated in areas of lighter brush growth and poor soil.

In summary, the increased number of *P. truei* captured in the ungrazed

ceanothus plot was associated with the abundance of ceanothus. Plottings of the captures of this species on the habitat maps of both the ungrazed plots clearly defined the brush occurrence with the greatest number of captures occurring in the most dense brush. Captures of *P. boylii* in the two plots corresponded to rock and boulder outcrops although several were made considerable distances from them and under ceanothus. *D. heermanni* captures were most frequent in the better drained sites of the two plots. This species preferred light ceanothus growth and areas of low grass density.

Moderately grazed ceanothus plot.—This area was chosen for comparison with the ungrazed ceanothus plot. It was situated in a pasture previously subjected to moderate grazing for three years and moderate to light grazing prior to that. The soil was better than in the ungrazed ceanothus plot. A wide belt of ceanothus crossed the plot diagonally, rock outcrops were comparatively rare, and digger pine and interior live oak infrequent. Ceanothus bushes differed from those of the previous plot in being less dense, browsed by cattle into rounded outline, lacking in brushy understory because of cattle activity among the bushes, and more open or "parklike" with grazed grass present under the ceanothus canopies up to the stems of the bushes. A few larger bushes with an understory reaching the ground had the shielded ground area badly disturbed by diggings of cottontails and other animals.

As in the previous plot, the majority of *P. truei* captures (over 80 %) were in the ceanothus belt. A few captures were made under interior live oak and digger pine, and one in swale. When released this species always ran to ceanothus; all homesites were under or in close proximity to these bushes.

A few *P. boylii* captures were made in that portion of the plot where several rock outcrops were situated. Three of the five captures were made under ceanothus canopies more than 10 feet from rocks. No captures were made in open swale.

P. maniculatus was captured eight times. Over half of these captures were made under isolated ceanothus bushes in a small swale, the remaining being near scattered rocks in open swale. None was caught in the ceanothus belt.

One *D. heermanni* was caught once in an unused roadway that ran through the ceanothus belt.

Under subjection to grazing of moderate intensity, habitats of the moderately grazed ceanothus plot were materially changed from those of the ungrazed ceanothus plot. These changes were of three types: Grazing of grass to a short height; trampling of soil and dead limbs (understory) of the ceanothus; and browsing of the exposed twigs on the surface of the bushes. Fewer *P. truei* were captured, presumably, because of the comparative sparseness of the bushes, elimination of protective understory of mature ceanothus, and its absence in the younger plants. *P. maniculatus* probably was present due to the effects of grazing on the swales. *P. boylii* showed no apparent differences in habitat between the two plots. No conclusions can be drawn from the single capture of *D. heermanni.*

TABLE 3.—*Frequency of captures of rodents made at four-foot intervals from ceanothus and rocks, and captures made in various grass densities more than 20 feet from rocks, bushes, or trees during the period between December 13, 1949 and March 7, 1950*

Distance from Habitat Features (in feet)	Number of Captures			
	Peromyscus truei	*Peromyscus boylii*	*Peromyscus maniculatus*	*Dipodomys heermanni*
Ceanothus				
0– 4	63	10	4	16
4– 8	16	3	0	7
8–12	7	1	2	3
12–16	5	0	0	4
16–20	2	0	1	0
Rock outcrops				
0– 4	30	45	12	9
4– 8	3	2	1	1
8–12	1	2	7	2
12–16	2	1	0	0
16–20	1	1	0	0
Grass over 20 feet from rocks bushes or trees				
None	0	0	2	1
Moderate	7	0	21	7
Heavy	0	0	0	0

SUMMARY

Live trapping of four-acre plots was undertaken at the San Joaquin Experimental Range in Madera County, California to determine the effect of cattle utilization upon habitats of small rodents. Four plots were chosen and trapped for seven or eight day periods.

Peromyscus truei was the most common animal in all plots, its abundance being almost proportional to the amount of ceanothus cover present (Table 3). If ceanothus was absent, this species utilized rock habitats sheltered by live oak bushes, a habitat that more generally produced *P. boylii*. The main effect of cattle grazing upon the habitat of *P. truei* was the opening up of the ceanothus bushes, which appeared to reduce the number of individuals using the area.

P. boylii was most commonly associated with rock outcrops (Table 3) and appeared to be in competition with *P. truei* for some of these rock sites, especially those near ceanothus bushes. Grazing did not appear to lower the probability of *P. boylii* being on rock outcrops despite the consequent increase in numbers of *P. maniculatus* in the vicinity. Either digger pine or interior live oak were present in all areas in which *P. boylii* was captured, but it is not known if these trees are required in addition to fractured rock outcrops in its habitat.

P. maniculatus was found only in open areas of plots that had been grazed (Table 3). In these plots it occupied the same habitat as *Dipodomys heermanni* and appeared to be unable to preempt habitats of *P. truei* or *P. boylii*. *P. manicu-*

latus was benefitted by grazing and was not found in plots protected from grazing.

D. heermanni was associated with bare or nearly bare soil and was not found in areas of tall grass or heavy grass litter (Table 3). Its greatest abundance occurred on bare soil under the protective canopies of ceanothus bushes in the ungrazed area. Evidently grazing of swales makes these areas more suitable to *D. heermanni* and *P. maniculatus*.

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AN INVASION OF NORWAY RATS IN SOUTHWEST GEORGIA

By Dean H. Ecke

There is a continuous struggle among animal populations to occupy and to maintain occupancy of any given territory, but it is only rarely that we are privileged to make first-hand observations of this phenomenon. This paper reports such an observation.

For hundreds of years two species of the genus *Rattus*, *R. norvegicus* and *R. rattus*, have been in direct competition with each other and to this day have not developed the ability to live harmoniously in a shared environment. Matheson (Jour. Anim. Ecol., 8: 76–93, 1939) reviewed the evidence of the Norway rat's successful replacement of the roof rat (black rat) over most of England in the 18th century. We know that both species of rats were introduced to this continent by the time of the American Revolution. Since that time careful observers have been aware of the existing competition between these two species when they occupy adjacent or overlapping habitat. The usual result was that the larger Norway rat dominated the smaller roof rat.

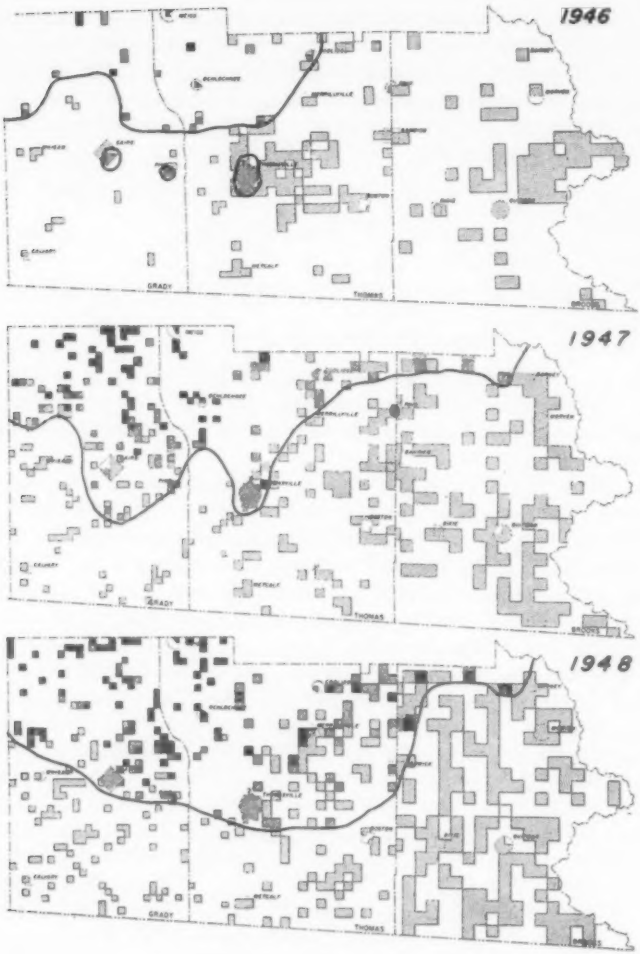
Observers in Georgia during the past six years (Hill and Morlan, Public Health Rep., 63: 1635–1653, 1948; Morlan, Utterback, and Dent, Public Health Monog.

Table 1.—*Numbers of rats captured in three southwest Georgia counties, 1946–1952*

	Grady		Per Cent Norvegicus	Thomas		Per Cent Norvegicus	Brooks		Per Cent Norvegicus	Annual Total of All Rats	Per Cent Norvegicus
	Rattus	Norvegicus		Rattus	Norvegicus		Rattus	Norvegicus			
1946	1054	194	15.5	1424	231	14.0	1798	0	0	4701	9.0
1947	1433	564	28.2	1486	440	22.8	2218	11	.5	6152	16.5
1948	1146	818	41.6	1992	860	30.2	2458	107	4.2	7381	24.2
1949	1372	1125	45.1	1514	1263	45.5	2428	350	12.6	8052	30.3
1950	232	292	55.7	203	296	59.3	458	112	19.6	1593	43.9
1951–1952	73	111	60.3	60	174	74.4	420	49	10.4*	887	37.7
Six-Year Totals.....	5310	3104		6679	3264		9780	629		28,766**	24.3

* A special effort was made this year to obtain *R. rattus* from Brooks County.

** 21,769 *Rattus rattus*, 6,997 *Rattus norvegicus*.



Rattus DISTRIBUTION FOR
GRADY, THOMAS, and BROOKS COUNTIES
GEORGIA —

FIG. 1

No. 5, 1952) have recognized a large-scale invasion of territory by Norway rats and have analyzed the data in relation to murine typhus epidemiology. The present paper is an attempt to interpret these data from an ecologist's point of view and to include some additional information. The data are based on detailed

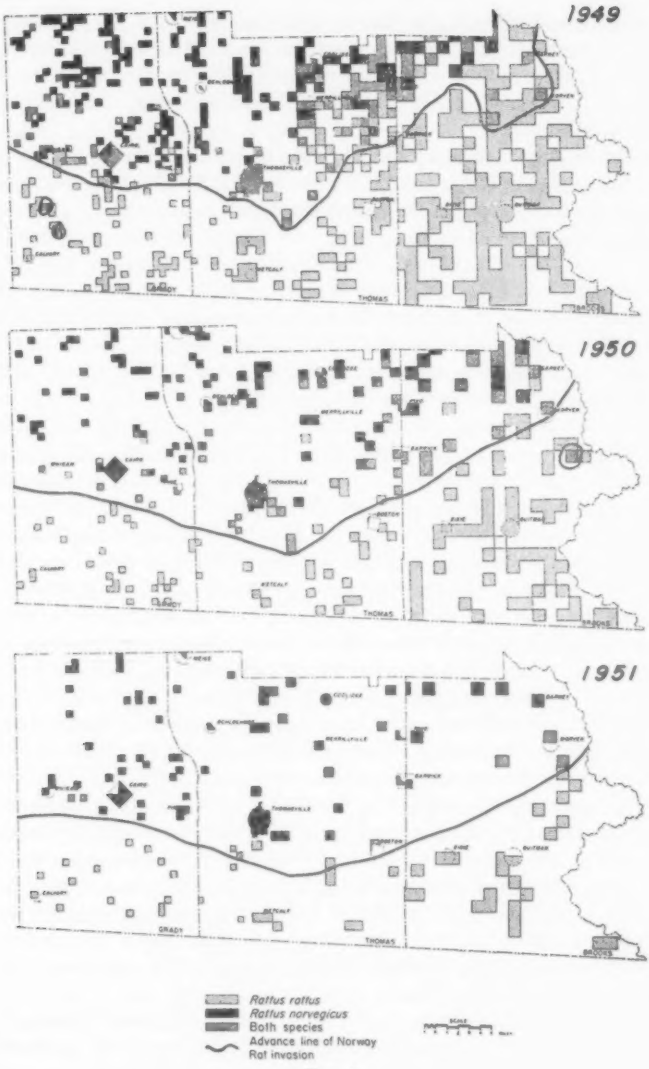


FIG. 2

trapping records collected in three Georgia counties between the years of 1946 and 1952.

The three counties (Grady, Thomas, and Brooks) in southwest Georgia are primarily agricultural and have many small farms which grow peanuts, cotton,

tobacco, corn, and other crops. The several small towns in these counties have little industry and cater largely to the farm trade. With minor exceptions, rat harborage exists in human dwellings and outbuildings, including small barns and corncribs, which usually are one to one-and-a-half stories high and of rather loose construction.

With the objective of sampling the rats of each county to obtain reliable county-wide trends in disease and ectoparasite distribution, traps were operated in 16 geographically representative zones of each county, and under most circumstances a fixed quota of 10 or more rats was obtained from every zone at least once a month. Trapping was conducted from January, 1946, through November, 1949; in June, July, and August of 1950; and from mid-August to mid-October in 1951. The records from occasional trappings between October, 1951, and March, 1952, have been added to the data for 1951. The total of 28,766 rats trapped over the six-year period consisted of 6,997 Norway and 21,769 roof rats (see Table 1 for detailed annual records).

Species composition was recorded from the beginning of the study, and the records of each unit area (subzone) were kept separate. By tabulating these data according to the subzones, it was possible to prepare species distribution maps that showed in which areas Norway rats, roof rats, and both species were trapped. In areas of mixed species composition there were some instances where both species existed on single premises for short periods of time (occasionally 2 or 3 months), but by far the majority of colonies were composed of rats belonging to only one species. A small number of isolated Norway rat records in the southern parts of the counties have been omitted because measurements suggest faulty identification or because the animals did not represent an established colony as was evidenced by further trapping. Possibly the only Norway rat in the area was the one captured. No special effort was made to concentrate trapping effort on one or the other species, and it is believed that trapping results are a relatively true indication of the species composition as it actually existed.

In 1946 all rat habitats trapped in Brooks County (Fig. 1), yielded only roof rats. Thomas County had large numbers of roof rats with a slight infestation of Norway rats in the northwest corner of the county. Thomasville, the largest town in the county, harbored a mixed population of both species. Northern Grady County had a few unit areas with only Norway rat populations; and unit areas with both species occurred throughout the remainder of the county as far north as the town of Cairo. South of Cairo, Grady County contained only roof rat populations.

In 1947 Norway rats had infiltrated the northwestern corner of Brooks County. During this same year, northwestern Thomas County and the northern one-third of Grady County also showed a considerable influx of Norway rats, with only a few remnants of roof rat populations remaining. The southern limit of the Norway rat invasion extended from the northwest corner of Brooks County, through Thomasville, to a point south of Cairo.

In each of the years from 1948 to 1950 (Figs. 1, 2), Norway rats progressed deeper into roof rat territory with the possible exception of one or two areas.

These apparent retreats could have been natural fluctuations; but they may be false indications from insufficient sampling because, within a given zone, not all rat colonies were trapped every year.

These comments leave the question of man's influence on this invasion largely unanswered, but in any event, it is apparent that Norway rats have spread in these three counties from the northwest, and at the end of six years they occupied two-thirds of Grady and Thomas counties and one-third of Brooks County. For the entire six-year period this invasion represented an average linear advance of approximately 20 miles and an overall occupation of 1,000± square miles (Figs. 1, 2).

That the spread was not affected by trapping, or any disturbing effect that this could have had on the balance of the two species, is indicated from results obtained in 1951. Specimens were difficult to find in the routinely sampled areas, but when the trappers caught rats in new territory, the pattern of species distribution was found to be similar to that of adjacent areas that previously had been trapped intensively.

Investigators in Southern cities have told the writer in conversation that on some occasions Norway rats and roof rats may coexist in overlapping habitat for comparatively long periods of time, but that such cases of coexistence have usually occurred in multiple-story dwellings where roof rats occupied upper stories and the Norway rats inhabited the ground floors and basements. As previously mentioned, southwest Georgia does not offer an abundance of multiple-story habitat. The record of the present invasion strongly suggests that the two species will not coexist on the same premises where there is competition for harborage as well as for food.

There are no reliable records of the species composition of rats in this region prior to the records collected during the past six years. It does seem significant that conversation with old-time residents reveals that Norway rats had not been observed until recent years. It would appear that this Norway invasion is a one-way trend that has not occurred in the region before. Subsequent observations may reveal whether or not the trend will reverse itself in favor of the roof rat. These observations recorded no observed instance where roof rats were capable of dominating premises to the exclusion of Norway rats once the latter had become firmly established (two or more breeding individuals).

SUMMARY

An illustration has been recorded of a Norway rat invasion through the greater part of three southwest Georgia counties that were formerly occupied almost entirely by populations of roof rats. The invasion overran about 1,000 square miles in six years. Norway rats not only invaded the new territory but, probably because of their larger size, were capable of dominating the competition for available habitats, thereby excluding the less dominant roof rat from most of the infiltrated territory.

14th Avenue and Lake Street, San Francisco, California. Department of Health, Education, and Welfare, Public Health Service, CDC. *Received October 1, 1953.*

FLUCTUATIONS AND STRUCTURE OF *PEROMYSCUS GOSSYPINUS* POPULATIONS IN EASTERN TEXAS

By W. H. McCarley

Studies on the dynamics of any natural species population are important since the individuals that make up a natural population are the basic units by which gene exchange is made possible between parts of a species population (Blair, 1953). In any given species the rate of gene exchange between various parts of the population will be influenced by such phenomena as population fluctuations, population structure, home range, social behavior, dispersal, breeding patterns and natural life span. This paper is a report of the fluctuations, structure, and breeding patterns of *Peromyscus gossypinus* populations in the timbered region of eastern Texas.

I am indebted to Dr. W. Frank Blair for critically reading the manuscript and Mr. W. N. Bradshaw for assistance with the field work.

POPULATION FLUCTUATIONS

In eastern Texas *Peromyscus gossypinus* populations undergo changes in density that can be correlated, to a large extent, with breeding pattern and environmental factors such as weather and available food supply. Most of the data concerning population fluctuations of *gossypinus* in eastern Texas are based on trapping records extending over a period from November, 1950 to June, 1952. These trapping records were compiled at 26 localities, representing 14 counties scattered throughout eastern Texas. Because this information is based on trapping percentages of more than one population and involves more than one locality, no conclusions can be reached as to actual population density in the majority of the cases. Unless specified otherwise, snap traps were used entirely in this phase of the study. The percentage catch was based on an average of 692.5 trap nights per month. Generally, no distinction has been made between sexes or age classes.

The *P. gossypinus* populations in East Texas generally reach their peak of highest population density during the winter months (Fig. 1). The peak was reached during the month of February in 1951, and in 1952 the peak was reached during the month of March. While the period over which this study was made was too short to be conclusive, the trends follow closely the general pattern that has been demonstrated by Blair (1951), and Pournelle (1952) on *Peromyscus* populations in the southeastern United States. The striking difference in apparent population size in the winter of 1951, as opposed to the winter of 1952 (Fig. 1), can probably be explained by a combination of environmental factors. The most important factor is probably climatic in nature. The summer of 1950 was generally cool, with a normal supply of rainfall, while the summer of 1951 was exceedingly dry and hot in eastern Texas. In 1951, the mice apparently did not reproduce to any extent during the months of July, August, and September, and very little in October. This could mean that the overall population size in the fall of 1951 was smaller than it was in the fall of 1950. This is indicated by Figure

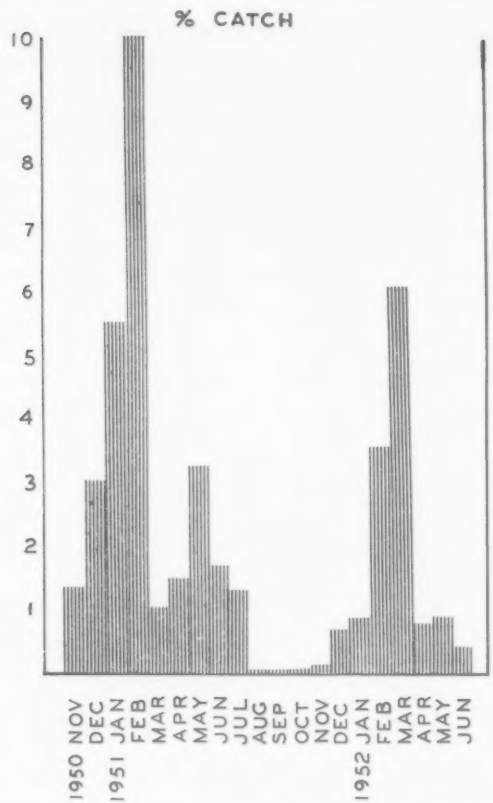


FIG. 1.—Fluctuations of *Peromyscus gossypinus* populations in eastern Texas for 20 months, based on percentage catch as indicated by trapping records compiled at 26 localities throughout eastern Texas.

1. Ordinarily there is probably a small amount of breeding taking place in these months. Pournelle (1952) demonstrated that, in Florida, from the latter part of April until August the reproductive activities of *gossypinus* are at a low ebb. He found that of 113 adult females examined during the months of June, July, and August, only one was pregnant. Pournelle was able to correlate these observations with environmental temperatures. He found that male *gossypinus* kept at a temperature of 89° to 101°F. were consistently not in breeding condition, whereas those individuals kept at 68° to 84°F. had viable sperm in the epididymis and tubules. If this be the case, then the abnormally high temperatures recorded in eastern Texas during the summer of 1951, might account for the lag in population increase in the winter of 1952. This lag would be the result

of a small breeding population at the beginning of the breeding season. Because of the drought of the summer of 1951, there was a decided decline in insect populations in eastern Texas as evidenced by general field observations made during the summer. If the food of *gossypinus* is made up, in large part of insects (Calhoun, 1941), then the scarcity of this food item could also have had a limiting effect on the populations.

The effect that the amount of available food can have in influencing the populations is well illustrated by the following: In the summer (June, July, and August) of 1952, prolonged trapping in connection with other work in East Texas revealed that the *P. gossypinus* populations had undergone the apparently usual summer decrease in numbers. In a locality, one mile east of Nacogdoches, a large amount of old grain and hay had been dumped on a creek floodplain. Live traps were set in the immediate vicinity of the refuse during the month of August when the populations were expected to be exceedingly low. For ten nights a ten per cent catch was recorded. One mile away from the dumped grain the catch was less than one per cent. Thirty-two of the 40 *P. gossypinus* collected here were in breeding condition. It is interesting that mice of this species collected elsewhere in East Texas at about this time were ordinarily not in breeding condition, and less than a one per cent catch was the rule. Thus, it would seem that amount of available food as well as temperature might influence the breeding pattern of *P. gossypinus*.

The very sharp drop in population size in March of 1951, as compared to the very sharp rise in population size in March of 1952 (Fig. 1), can probably be explained by the difference that existed in weather conditions during these seasons. In 1951, the month of February was exceedingly cold with a great deal of snow and ice. These conditions were not present in February of 1952. On the contrary, during February, 1952, exceedingly mild weather prevailed with no snow or ice. It would seem that there could have been a winter kill in February of 1951 that did not take place in 1952.

Two other species of *Peromyscus*, *P. leucopus* and *P. nuttalli*, were trapped along with the *gossypinus*. The additional species of *Peromyscus* were not as abundant in East Texas as *gossypinus* but the evidence that is available for these two species indicates that *leucopus* and *nuttalli* populations undergo the same seasonal changes in population density as does *gossypinus* and that their breeding patterns are similar to *gossypinus* populations.

In view of the apparent trends indicated by Figure 1, and by the work of Blair (1951), Pournelle (1952), and others it would seem that *Peromyscus* populations in the southeastern part of the United States are characterized by a drop in population size in the summer months and a gradual increase in population size beginning in September or October and continuing until February or March. From February or March there is a gradual decrease in population size until breeding is resumed in the early fall. It is also obvious that populations are greatly influenced by local environmental conditions and that in some cases these general trends can be completely reversed by local conditions. It is interesting to note that in the northern part of the United States where the winters are

more severe, *Peromyscus* populations do not breed in the winter but do breed in the summer (Burt, 1940).

POPULATION STRUCTURE AND BREEDING PATTERNS

It is obvious that as a dynamic unit a population is constantly changing its composition. The total number of individuals may be the same at two given times but it is not likely that at any two times the population will be composed of the same individuals nor the same proportion of age groups or sexes. This fact can be attributed to the action of environmental factors which may act differently on different individuals. Howard (1949) has shown that in *Peromyscus maniculatus* populations there was a difference in mortality rates among individuals of different age classes and among individuals born at different seasons of the year. It has also been shown by Howard (1949) that as the number of individuals increases in a population there is a corresponding increase in rate of dispersal. Howard (1949) has also demonstrated that there is a difference in dispersal rate among individuals of different age classes. Thus, it is apparent that there are many factors affecting the structure of any natural population. Blair (1951) believes that population changes are the result of: (1) the death or disappearance of a resident animal, (2) the movement of maturing young animals away from the area, (3) the appearance of immature animals that were either born there or that moved there from other areas, (4) the appearance of transient or immigrant adults and, (5) the sexual maturation and establishment of residence of juvenile mice.

One locality in East Texas was trapped consistently for one year, dating from January, 1951, until December, 1951. This place was located 15 miles southwest of Nacogdoches and was about 20 acres in area. It was not an isolated tract of timber but was continuous on three sides with the lowland forest of the Angelina River floodplain. As a result, the animals studied must be considered as only a segment of a larger population. This area was chosen because of its accessibility and because of the presence of logging roads running through and around the area. The study area was trapped twice a month, usually around the first and again near the middle of the month. Live traps were used entirely in this study. The mice were marked by toe clipping and were not marked individually but according to the first month they were caught on the area. Consequently it was not always possible to definitely distinguish between individual mice. It was unlikely that in any one month all of the individuals living on the study plot were trapped. Because the traps were always set for two nights at each trapping period (80 traps per night) the data shown in Table 1 probably give a reasonably dependable representation of the structure of the population over a year's time. The animals were arbitrarily divided into three age classes as follows: (1) adults, those individuals that were completely in adult pelage and which were at least three months old; (2) subadults, those individuals which were partly in adult pelage and partly in juvenile pelage and which were between one and three months old; and (3) juveniles, those individuals that were completely in juvenile

TABLE 1.—*The structure and estimated population density for 12 months of a segment of a population of Peromyscus gossypinus, 15 miles southwest of Nacogdoches, Texas*

Month	No. of Adults	No. of Subadults	No. of Juveniles	Total	Estimated Population Density
January	21	2	23	46	2.3/acre
February	17	10	28	55	2.7/acre
March	26	12	10	48	2.4/acre
April	17	15	4	36	1.8/acre
May	13	5	8	26	1.3/acre
June	10	5	2	17	.9/acre
July	12	2	0	14	.7/acre
August	10	0	0	10	.5/acre
September	6	0	0	6	.3/acre
October	6	0	2	8	.4/acre
November	7	1	8	16	.8/acre
December	13	5	12	30	1.5/acre

pelage and were less than one month old. This correlation of age with pelage condition is in accordance with findings of Pournelle (1952).

If one assumes that the number of individuals caught on the study plot for each month represents a reasonable approximation of the total resident animals, then one can calculate approximate population densities (Table 1). Because the study area was continuous with other similar ecologic areas some of the individuals would probably have only a part of their home range on the study plot. This fact would make the estimated population densities subject to additional error. There was little difference in the population densities for the months of January, February, and March although there were considerable differences in the composition of the population. From April until September, the population gradually decreased in numbers of individuals. From August until October, however, the population remained essentially constant and was composed mostly of adults. In October the first evidence of population increase was shown by the appearance of juveniles. This increase was even more apparent in November and December.

The greatest number of juveniles was present in the population during the months of January, February, November, and December, when the population was made up respectively of 50, 51, 50 and 40 per cent juveniles. From the latter part of February until June there was a gradual decrease in the percentage of juveniles in the population. The month of May was an exception because, here, there was a slight increase in the number of juveniles over the preceding month. This indicated an increased amount of breeding in April. During the months of July, August, and September no juveniles were found in this population.

As would be expected, the number of subadults making up the population followed the trend set by the juveniles. There were, however, usually fewer subadults than there were juveniles of the preceding month. This could possibly be attributed to a higher mortality rate among the juveniles than among other age classes.

The percentage of adults in the population varied considerably. The smallest percentage (31%) of adults found in the population was during the month of February. Actually there were only three less adults caught in February than in January when 45.5 per cent of the population was made up of adults. In general, there was a gradual increase in the percentage of adults in the population from March until August when the entire population was composed of adults. August and September were the only months of the year when the population was composed entirely of adults. This could be taken to indicate that no breeding had taken place during the months of July and August.

If one assumes the gestation period of *Peromyscus gossypinus* to be between 23 and 30 days as reported by Pournelle (1952), then it is possible to determine the pattern of breeding from the percentage of juveniles in the population for each month. The first juveniles appeared in the month of October and 25 per cent of the total population in this month was made up of juveniles. Because no juveniles were caught during the month of September, it is reasonable to assume that in this population in 1951, breeding began in September. Because there was a gradual increase in the number of juveniles in this population from September until the latter part of February and a gradual decrease from then until July, when no juveniles were caught, it would seem that some breeding had taken place in every month of the year with the exception of June, July, and August. As more juveniles were found during the months of January and February than in any other months of the year, one can conclude that in East Texas, as represented by this population, the greatest amount of breeding takes place during the months of December and January. This is borne out by the fact that the greatest numbers of pregnant females were collected elsewhere during December and January.

None of the adults that were trapped on the area in January was still present in December. Of those juveniles marked in January, only two, both females, were still living on the plot in December. Of the 28 juveniles marked during the month of February, only ten were found to be living on the plot in early April. Of the six adults that were present on the plot in October, only three were marked on the plot as juveniles.

It was apparent from this limited study that a rapid turnover occurred in the composition of the population. Individuals were found in the trapping area that were not marked on the plot as juveniles or subadults, and animals that were marked on the plot as juveniles, subadults or even adults were continually disappearing. Thus it would appear that there is a more or less continual exchange between the different parts of a large population due to the random movement and disappearance of individuals.

SUMMARY

Studies extending over a 20-month period show that *P. gossypinus* populations in eastern Texas fluctuate in size. These fluctuations are apparently correlated with climatic and environmental conditions. Ordinarily the population density is highest in January, February, and March, and lowest in July, August, and September. These general trends can, in some cases, be completely altered by

local conditions. Available evidence indicates that *Peromyscus leucopus* and *P. nuttalli* populations undergo the same seasonal fluctuations in population size and are probably influenced by the same environmental conditions as are the *gossypinus* populations.

A detailed study of a segment of a population of *Peromyscus gossypinus* indicates that there is a continual change in the structure of *gossypinus* populations. The largest percentage of adults is found during the summer months, while the largest percentage of immature animals occurs in the winter months. This indicates that the peak of the breeding season for *gossypinus* in eastern Texas is in the late fall and early winter.

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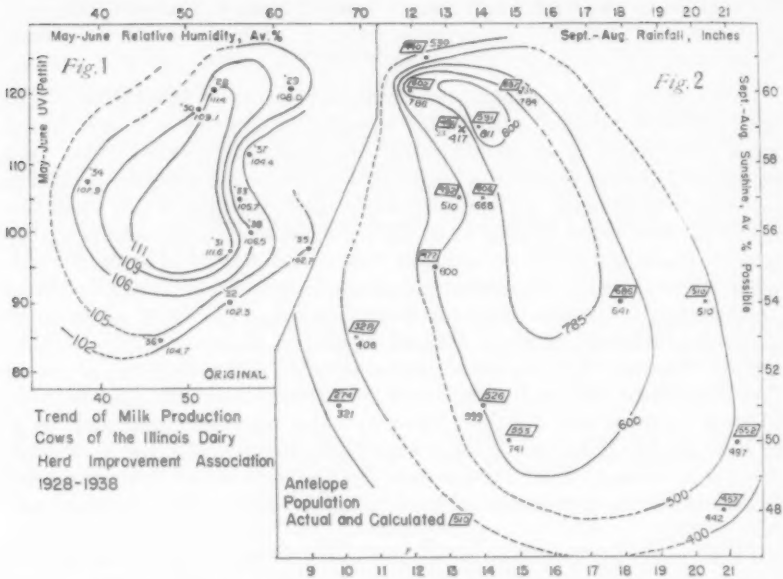
THE ANTELOPE POPULATION AND SOLAR RADIATION

By V. E. Shelford

In the course of animal population studies, evidence was found that optimal solar ultraviolet radiation intensity is a reproductive stimulus for a short critical period, and that it is apparently paired with moisture (Shelford, 1951). In a population, there is doubtless a considerable difference in dates of the critical condition in individuals. The stimulus is effective in a period of two weeks to a month or more before mating, while the reproductive cells are developing. Intensities above and below the optimum range are indicated to be detrimental. Observations on quail, cottontail rabbit, house wren, and chinch bug populations support these conclusions. These conclusions are also supported by experimental work with ultraviolet, a) which reduced the pre-oestral period of a ferret (Marshall and Bowden, 1934), b) which induced breeding with more young of greater vigor than those induced by white light in the case of an orthopterous insect (Sabrosky, Larson and Nabours, 1933), c) which increased egg production of poultry, (Bailey, 1950) and d) which induced reproduction of a pair of monkeys as noted by Stetson (1947). Furthermore high temperature and light were found to be essential to maturation in the four-spined stickleback (Merriman and Schedl, 1941).

We are reminded of solar radiation and its ultraviolet by an occasional sunburn in spring, summer, or even in winter. Antelopes on the plains have little chance to escape solar radiation. They must receive the ultraviolet and its variations, as there is not much in the environment or the habits of the species (*Antilocapra americana*) to indicate that they find shade to any noticeable extent.

In the study of populations, sensitive periods in the life history, or in the annual physiological cycle of long-lived species such as the antelope, must be given close attention. It has been quite clearly demonstrated that a period in or shortly before the rutting season is important in the case of sheep (Johnson, 1926) with reference to variability of temperature, and temperature and moisture in combination. The second sensitive period in mammals is the season when the young are born. At this time the milk production is a sensitive function. In the domestic cow, milk secretion is evidently influenced by ultraviolet; butter fat content appears to be influenced (Shelford, 1952*a*). The same appears to be true of the amount of milk produced (Fig. 1). This figure suggests that ultraviolet 95–120 and humidity 45–58 per cent is a combined or paired optimum. Figure 3-4 shows that the largest population of antelope (800) in this study falls in the same factor area. Johnson (1926) drew figures very similar to Figure 1 except that he, at least in principle, merely called an area similar to the 111 area of Figure 1, "optimum" and the space on the same figure between 111 and 106 as favorable with 109 ignored. Figure 4 is drawn on the same principle. The operation of two factors in a paired manner is not difficult to understand if one recalls that Abbe (1898) found temperature and humidity operating together to produce a sensation of comfort. He found that he was comfortable at temperatures of 80°F. with 20 per cent relative humidity, 40°F. with 60 per cent relative humidity, and 60°F. wit


May-June Relative Humidity, Av. %
May-June UV (Petit)
Fig. 1
ORIGINAL
Trend of Milk Production Cows of the Illinois Dairy Herd Improvement Association 1928-1938
Sept.-Aug. Rainfall, Inches
Sept.-Aug. Sunshine, Av. % Possible
Fig. 2
Antelope Population Actual and Calculated

FIGS. 1 and 2.—The May-June milk production of 15 to 25 thousand producing cows of Illinois Dairy Herd Improvement Association in relation to daytime humidity and solar ultraviolet, 1928 through 1938. The greatest milk production lies between 97 and 119 on the ultraviolet scale and between 51 and 56 per cent on the humidity scale.

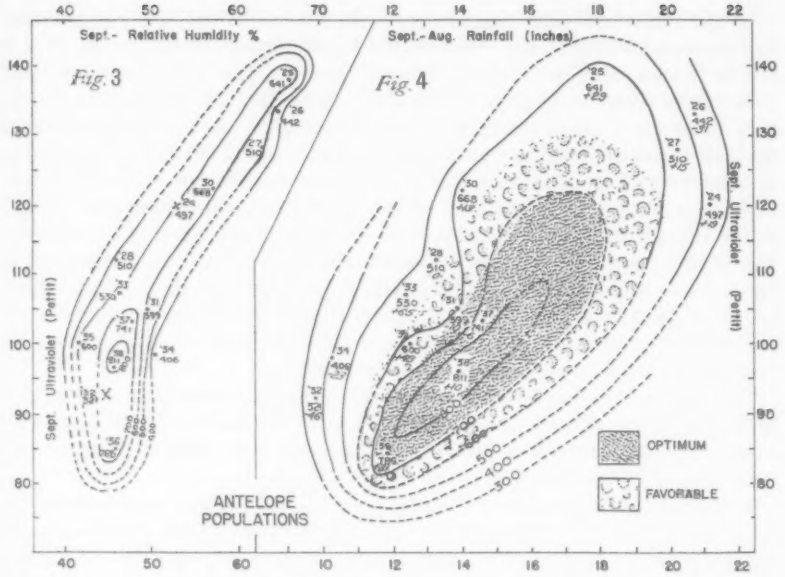
The population of antelopes in Yellowstone Park as counted in February, 1924 through 1941 (no count in 1931) in relation to annual per cent possible sunshine (Sept. through Aug.) and annual rainfall. The population data are plotted with reference to the September premating period of the second preceding calendar year. Only the items not on Figures 3 and 4 are dated. The largest populations were associated with rainfall of 11.5–15.0 inches and sunshine 58 to 65 per cent. The framed figures are calculated trend eliminated figures. The sharp contrast between 417–811 is probably the result of trend. 417 near the top of the figure at the left marked by X is discordant but was a large figure for the first year of study. It becomes 481 when the trend is eliminated while 811, the largest count, made in 1940 becomes 591.

80 per cent relative humidity. This is explainable in consideration of the temperature regulating mechanism of man and other mammals.

This approach to population problems from the standpoint of two factors operating together assumes, probably rightly, that the basic control of numbers lies in the reproductivity of the species concerned, i.e., in the number and vigor of offspring. It is not until fecundity is understood that survival can be scientifically approached.

ANTELOPE

With the facts relative to other organisms, especially the sheep and dairy cows, as background, it is the purpose of this paper to investigate changes in the



FIGS. 3 and 4.—The ultraviolet hydrogram based on September conditions. September is assumed to be the period of reproductive stimulation. The population data are plotted on the weather of the September of the second preceding calendar year. Discordant values are marked with an X. The high populations fell between 85 and 120 on the ultraviolet scale and between 45 and 58 per cent relative humidity.

An ultraviolet hydrogram using the same September radiation data as in Figure 3, with the annual rainfall (Sept. through Aug.) The plotting is on the September ultraviolet of the second preceding calendar year. This is not a physiological paired factor diagram but gives a more general picture of the effect of moisture on the population including gestation and growth of young. The figures in italics indicate percentage increase and decrease from the previous year's population. They are more variable, being dependent on the size of the population. Areas for optimum conditions and for good conditions are shown.

antelope population in Yellowstone Park from the standpoint of paired factors, especially solar radiation and moisture.

In Yellowstone Park the peak of mating falls in October after a long period of decreasing day length (Bissonnette, 1941). By inference from the cottontail rabbit and the quail, this would put the sensitive period of gonad development and reproductive stimulation in September (Ecke, 1948, Shelford, 1951). If stimulation by an optimum intensity of ultraviolet in combination with suitable moisture resulted in more offspring and at the same time more vigorous offspring, it could be evident even if the count was made eight months later (Fig. 3) and 17 months after the mating took place. The young are born in June and by September are half the weight of the adults (Heller, 1925), and in spite of considerable mortality (Buechner, 1950) there appears to be some order in population changes.

In the Park herd there appears to be an increase trend in the population. Statisticians insist that the trend should be eliminated, especially where it is due to human interference as might have been the case in Yellowstone Park. Yellowstone Park antelope were especially benefitted by an addition to the park below Gardiner in the early 1930's. Nevertheless the trend figures reduce the year to year differences in calculated population and change the percentage of differences. This percentage is shown by italics on Figure 4. All the annual percentage increases are less and all the annual percentage decreases greater in the trend calculated population than in the figures for actual populations. The annual percentage average increase is nearly 12 based on a comparison of the first and last three years (1923–1941). In all probability the original figures are more significant than the trend figures for the purpose in hand. However, they are shown framed in Figure 2 because of discrepancies probably resulting from an increase trend suggested by the data.

The antelope counts (see acknowledgements) made in February are as follows: 1923, 320; 1924, 417; 1925, 417; 1926, 497; 1927, 641; 1928, 442; 1929, 510; 1930, 510; 1932, 668; 1933, 599; 1934, 321; 1935, 530; 1936, 406; 1937, 600; 1938, 786; 1939, 741; 1940, 811; and 1941, 784.

There was no count in 1931. The 1924 through 1938 counts were selected because there were solar ultraviolet records for that period; the 1940 count was perhaps influenced by the 1938 mating period. Counts for the earlier years were for 1921, 350 and 1922, 253; these and 1941 were secured after the paper was practically completed. Four hundred seventeen is a high population for the first three years, and 811 for the last three years. In Figure 2 the two stand quite close together from the standpoint of physical factors, and the calculated values approach each other as 481 and 591. Figure 2 was attempted on the assumption that sunshine and moisture operate together in influencing the well-being of the antelope throughout the year. If equal population lines can be drawn through the population data, it is assumed that the two factors operate together concurrently just as temperature and moisture do in giving us a sensation of comfort (Abbe, 1898). The physiological processes in the case of comfort are well known. While this type of analysis is not familiar to many biologists, there are a hundred or more such diagrams in scientific literature based on 20 or more combinations of factors and involving several representative animal groups. Many of the results are from extensive experimentation (Shelford, 1952*b*, *c*).

Equal antelope population lines are indicated in Figures 2, 3 and 4. They resemble parallel ellipses (Fig. 1). European workers have used terminology for these that would lead us to call Figure 2 a heliohydrogram.

To test the ultraviolet, Figure 3 was drawn with relative humidity and Pettit's Mt. Wilson ultraviolet indices from the International Astronomical Union (1924–1938). The figure was better than might be expected, the largest population falling on about between 85 and 120 on the ultraviolet scale and relative humidity approximately 45–58 per cent. The 1932 figure is very discordant and probably due to drought failure of the food supply. These diagrams can serve to point out the action of other factors.

Because moisture may have important relations to antelope welfare throughout the year, Figure 4 was drawn. It indicates an optimum annual rainfall of 14 inches. Italics here indicate actual percentages of increase and decrease. This is not a physiological paired factor diagram but is intended to show optimum, good and tolerated conditions as well as populations.

These diagrams may be compared with a more familiar type exemplified by the work of Johnson (1926), who maps the favorable rutting period and favorable lambing period for sheep on the basis of temperature and moisture. With extensive records of English sheep growers' journals he was able to map favorable months and favorable entire years. In the case of the antelope, Figure 2 is similar to Johnson's figures but in greater detail. The 785 ellipse could be used as the probable conditions of a good year and the zone between 785 and 600 the conditions of a fair year. Shelford and Yeatter (1954) have found similar relations in the case of the prairie chicken.

A study of Figure 3 shows that 93 on the ultraviolet scale and less than 45 per cent RH were associated with a big drop in population in 1932 which is shown as 46 per cent on Figure 4. From these facts we may infer that annual rainfall less than 10 inches with September ultraviolet at about 93 is very unfavorable. Figure 4 shows that such conditions were associated with a 46 and 23 per cent decrease. It is probable that increases and decreases of much less than 20 per cent cannot be considered as being of significance from the standpoint of radiation due to the operation of other factors. Also a few added individuals give a large percentage increase for a small population and vice versa. In Figure 2 the difference of 811 in the 800–900 category following 1938 weather, as compared with 417 in the 600–785 category following 1923 weather, represents the effect of trend over 15 years with 1938 evidently very favorable. Other discrepancies result from similar relations to trend.

SUMMARY

There is evidence of sensitive periods in which the size of population increase may be determined. Light appears to be an effective factor influencing fecundity in antelope and probably also milk production.

Light is apparently paired with moisture so that a large series of combinations can produce the nearly same results while separate linear graphs of the factors indicate little.

The diagrams presented are suggestive but not authoritative. This is due to the facts (a) that physical factors used were not measured alongside the herd, (b) that we do not know which moisture is effective, atmospheric, soil, or food, and (c) that the counts were badly timed for the purpose.

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NOTES ON THE HABITS OF THE BAT, *MYOTIS CALIFORNICUS*

By Philip H. Krutzsch

Myotis californicus ranges over much of western United States and Mexico. However, in spite of its wide distribution, there is little on record in regard to its natural history.

Data presented here were gathered as part of a general study of the bats of southwestern California and were obtained primarily in June, July, August and September of 1946, 1948, 1949, 1951 and 1953. Field notes were also accumulated in the winter months of the years 1936 to 1943.

In San Diego County, *Myotis californicus* is known to occur from the sea coast to the desert and inhabits the Lower and Upper Sonoran and Transition Life-zones. In the desert areas these bats are most frequently found in the vicinity of water either near rocky canyons where mesquite (*Prosopis*) and catclaw (*Acacia*) are growing or on the sandy flats where creosote (*Larrea*) is the dominant plant. West of the desert bats favor riparian groves of sycamore (*Platanus*), willow (*Salix*) and cottonwood (*Populus*); they also favor oak groves and open forest (either deciduous or coniferous).

It seems likely that *M. californicus* is primarily a crevice dweller in that most of the roosting sites selected are in narrow and crevice-like places. These bats frequent such retreats in small numbers or singly. During the breeding season females may gather in nursery colonies and will habitually occupy a specific roosting place for much of the summer season. Except for occasional nursery colonies it seems likely that males and females, including females with young, move about without regard to any particular, habitually used, hiding place. They apparently roost in the most available site when their evening foraging is completed.

Numerous observations of the following nature offer evidence for this statement. A bat was taken from a fold in a temporary canvas shelter less than 24 hours after the shelter had been erected. Another bat was obtained from a small space between rafters where bats were not present previously. An individual was taken from a small space, previously unoccupied, between supporting beams of a wooden bridge. An old rag hanging inside an unused building served as a hiding place for two adults with young, where earlier examinations had disclosed none. Bats taken from such sites have been marked and released, but subsequent searches of these roosts for the marked individuals have been unsuccessful. *Myotis californicus* has been obtained from various temporary hiding places in old wooden houses, unused wooden shower rooms, wooden barns, wooden stables, wooden bridges, behind sign boards, in mine tunnels and under canvas shelters. In areas where man-made roosting places are not accessible bats have been found in hollow trees and beneath rock flakes and loose bark.

Most retreats are utilized only at intervals and are not marked by accumulated droppings and urine stains, factors common in the long and habitually used diurnal roosts of the nursery colonies.

The record of one nursery colony is of interest. On May 1, 1943, at Hulbard Grove, two miles north of Descanso, a nursery colony of *M. californicus* was discovered behind a plywood sign on the south door of the horse stables. At this time there were 25 individuals in the colony, of which eight adult females were collected. The remainder of the bats were disturbed and flew from the roosting site; however, all returned to the sign board after a few minutes of flight. On subsequent visits, September 2, 1943, and July 20, 1946, bats were present in the stable. The September 2 visit found them behind a tin sign on the north door. Five adult females and one immature male were collected; several other bats were seen but not obtained. On July 20, 1946, the bats were utilizing a space between the wallpaper and wall-sidings of a storage room; two adult females and five immatures of both sexes were collected. The tin sign occupied in September, 1943, had since been removed and the plywood sign converted to a blackboard which was in constant use and probably, because of this continual disturbance, was unsuitable for a day-time retreat. This nursery colony, although frequently disturbed, habitually occupied the same building. Bats were usually present, according to the owner, from June until late August and had roosted there, as far as he could recall, for "at least 10 years."

The adults of the two sexes appear to be separated much of the year. In the months September, October, February and March adults of both sexes have been found roosting together, nevertheless, the sexes are frequently found separate at this time, as is true of summer roosting. Apparently breeding occurs sometime in the fall or perhaps early spring, as I have no record of adult male and female *M. californicus* being found together in a diurnal roost (infrequently both sexes use the same night roost) earlier than September and after March.

Myotis californicus has a single young. There is evidence that the date of birth varies considerably. Young of several sizes and states of maturation have been found in a single colony. Males taken in September and October have enlarged testes and are assumed to be capable of insemination. This is indicative of delayed fertilization, as in the eastern *Myotis l. lucifigus*. Therefore, if delayed fertilization occurs, it is not improbable that the variation in the development of the young is a result of differences in time of ovulation rather than differences in time of copulation.

No pregnant females were obtained after mid-June, indicating most, if not all, young have been born by this date. Data on ovulation and early pregnancy are not available, although gross signs of late pregnancy were recorded. A female taken April 30 contained a small embryo in the right horn of the uterus, two obtained on May 1 had the right horn much swollen and were believed to be pregnant, another taken on May 21 had a near term embryo in the right horn. Several females with young attached were observed on June 20, one baby was fully furred and almost adult-sized; a second was small and hairless. This discrepancy in development indicates a wide range in parturition dates. On July 20 three lactating females and four young were found. Three of the young were nearly adult-sized and able to fly; the fourth young was smaller than the others and incapable of flight. An adult female taken August 7 had recently ceased to

lactate, but the mammae were enlarged; a female taken August 20 had teats much reduced, although the areolar area was distinct. The testes of adult males obtained in the late spring and summer were tiny and abdominal, therefore, presumably, inactive.

Night roosting is common to various species of *Myotis* and, as Dalquest (Amer. Midl. Nat., 38: 241, 1947) points out, affords a means whereby late flying and solitary diurnal roosting species can be obtained when otherwise they are difficult to collect.

This species frequently retires to a resting place several times in the course of their foraging. They utilize open buildings near their feeding grounds where they enter and "hang up", presumably between foraging flights. Almost any open room, porch, or corridor will serve. I have found individuals utilizing garages, barns, houses, outbuildings, bridges and corridors, as well as porches, of schools and churches. Most of the structures were wooden but several were adobe or cement. Shelter from the wind, darkness (no porch or street light) and proximity to the foraging areas utilized by the bats are possibly factors of importance in the selection of such roosting sites. At least all such sites that I have observed have those things in common.

Myotis californicus begins foraging in the early evening soon after sunset. They feed rapidly and fill their stomachs in a short time, often retiring to a roosting site near their foraging grounds a few minutes after darkness. Such foraging, spaced by periods of rest, probably continues until dawn.

On August 7, 1946, at the Hormigero Ranch, 6.6 miles northeast of Pala, sunset occurred at 6:43 PM. At 8:00 and 8:02 PM, less than an hour after darkness, bats were found hanging on an overhead beam in the main cabin of the ranch. This cabin is located in a grove of live oaks (*Quercus agrifolia*), and bats forage regularly each evening under the trees. The ranch owner informed me that small bats often fly into the cabin to "hang up" and recalls having seen bats in the cabin at intervals until just before daylight.

The old Butterfield Stage Station at Vallecito has long been a favored site for night roosting bats. The surrounding terrain today is much as it was described by Frank Stephens (see Dalquest, Jour. Mamm., 28: 26, 1947). The stage station has since been restored. Nevertheless, it is much used as a night roosting place by various species of bats. The building now has five rooms, each opening to the outside either by door or window or both. It has been the practice of the custodian to leave doors and shutters ajar, and through these openings bats gain their entrance. A number of species of bats roost in the station, and the California myotis was usually found roosting with one or more of these species. Numerous visits to observe and collect *Myotis californicus* have been made to the Vallecito Station, and on occasions an entire night has been devoted to observation of this species. One such period of observation, on July 29, 1953, was made in company with J. R. Homesley. We approached the building at 9:00 PM. Bats were seen flying over the mesquite trees in the station yard, in the open corridor of the porch and in and out of the open doors and windows of the station. The night was warm (95°F), clear (moon at three quarters) and

windless. There were numerous insects flying and many were attracted to the light of our gasoline lantern.

We entered the station and closed the doors and shutters. In the west and center rooms there were three California myotis and two leaf-nosed bats; all were clinging to the overhead beams. The rooms on the east and west contained two individuals of *Myotis californicus* and one *Eptesicus fuscus*. The former were in flight and the latter was at rest on an overhead beam. The small room on the north side of the building sheltered five leaf-nosed bats and one *Myotis californicus*. After we completed our search the doors and shutters were again opened while we weighed, sexed and removed parasites from the bats just captured. As we did this, several bats were observed entering the building, seemingly unmindful of the strong light of our gasoline lantern. All bats taken had abdomens distended, presumably with food.

Searches were continued at 30 minute intervals until 2:00 AM. In each instance the same procedure was followed. All bats trapped within the building were captured and retained in order that an inventory of the population of the station and its composition be ascertained. Although bats of the species *Myotis californicus* were most numerous, they shared the station with six other species: *Antrozous pallidus*, *Corynorhinus rafinesquii*, *Eptesicus fuscus*, *Macrotus californicus*, *Myotis subulatus* and *Pipistrellus hesperus*. Usually one or more of these species were present, but occasionally *Myotis californicus* was the only species found.

It is interesting to note that although *Pipistrellus hesperus* is abundant in this area (probably the most abundant species) only a single individual was taken. The composition of the population in the station at different periods in the evening is of interest. *Macrotus* was present in good numbers from 9:00 PM until midnight and absent thereafter; *Corynorhinus rafinesquii* appeared at 11:00 PM and disappeared at 1:00 AM. The small number of individuals of other species obtained (*Myotis subulatus*, *Antrozous pallidus* and *Eptesicus fuscus*) leads me to suspect that they are less numerous in the area. At 2:00 AM (the last search) an adult female *Myotis californicus* was the only bat in the station.

A summary of data obtained from this and other visits (Fig. 1) indicates that bats are most numerous in the station from 9:00 PM to 12:00 midnight. Thereafter there is a gradual decrease in numbers. Observations are not available beyond 2:00 AM, hence it is not known whether activity again increases in the pre-dawn period.

Visits to the station in the months June, July, August and September always disclosed night roosting *Myotis californicus*. However, visits in the winter months were not always successful; presumably the cold weather and absence of flying insects were factors in the lack of activity. Nevertheless, bats were found frequently enough during this period to indicate their continued occurrence in the area.

Myotis californicus begins foraging prior to darkness and continues until the early hours of the morning. Foraging is done near the ground, frequently at heights of less than ten feet. Quite often bats stay near vegetation in their

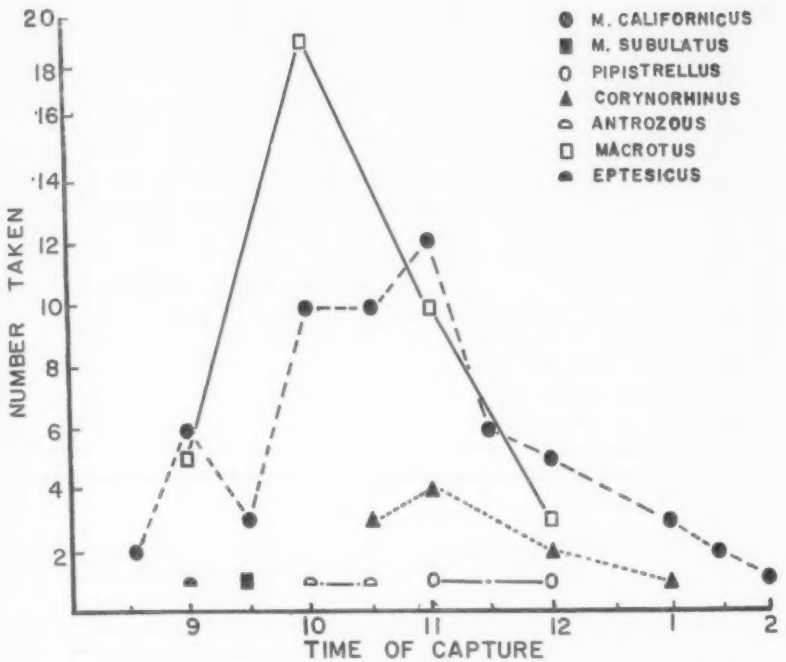

FIG. 1.—A summary indicating the hour of appearance and disappearance and number of each of the various species of bats observed or obtained at the night roosting site in the old Butterfield Stage Station, Vallecito.

search for food. The height of the foraging flight, therefore, varies somewhat according to the vegetation level at which food material is most abundant. Quite often bats of this species are found foraging around live oak trees. It is possible that the attraction is the summer-abundant oak moth. At El Monte Oak Park in the summer of 1938, I observed a number of these bats hunting insects about the outer edges of the branches of the live oak trees. The bats were seen circling around the trees; their flight was regular, and the only changes of direction were made in pursuit of moths. Most of the bats were foraging 10 to 12 feet above the ground where moths were most in evidence. At Camp Marston, Pine Hills, in the summer of 1947, bats of this species were commonly observed foraging in the open space beneath the lower limbs of a mixed growth of yellow pine (*Pinus*) and black oak (*Quercus*). The bats frequently appeared on the wing before sundown. The deep shade offered by the dense foliage may have influenced this early foraging. In desert areas where vegetation is low and more sparse, *Myotis californicus* forages near the ground, flying close to the tops of the vegetation. At Agua Caliente Spring bats of this species were seen on the wing shortly after sundown. Circling above and around the catclaw and mesquite trees they

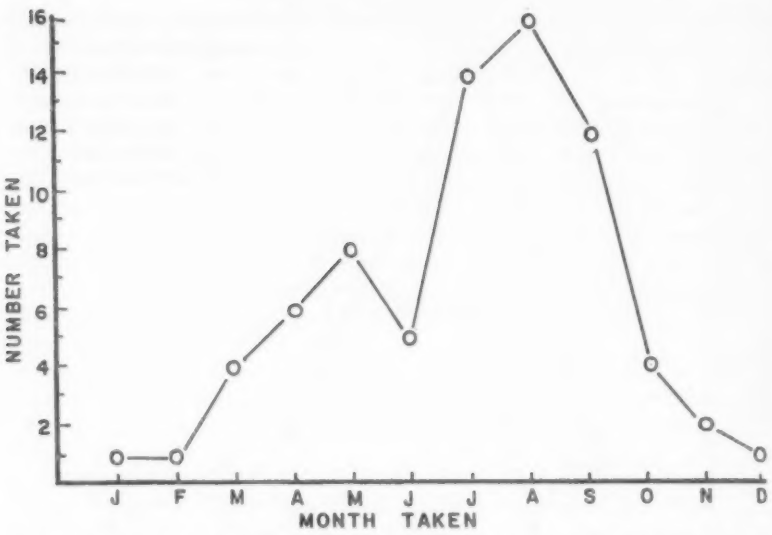

FIG. 2.—A record of the bats taken (excluding those observed) in each month of the year during the period of observation. Note reduced numbers in the winter months.

made frequent sharp changes of direction upward or to the sides, but usually not downward. Those seen foraging over the swampy area south of the Vallecito Stage Station flew low above the brush. At Palm Canyon, Borego Valley, *californicus* appeared as darkness deepened, and they flew through the heavy growth of willow bordering the stream.

Myotis californicus appears to be entirely insectivorous in habit. Droppings collected from beneath their roosting places have contained the finely masticated parts of unidentifiable insects. Stomach analysis likewise indicates an insect diet. The utilization of the oak moth as food offers a clue to one type of food obtained.

Little California bats go to open water to drink soon after emerging from their diurnal retreat. These bats apparently seek water several times during the night, certain favored watering places being repeatedly utilized. At Palm Canyon, Borego Valley, a small pool overhung with willow served as a watering place. Bats approached the water in a glide with wings set about 70 degrees from the vertical. Near the surface of the water the glide is checked and flight changes to a fluttering motion, the bats moving slowly above the water. Individuals were seen to bend their heads forward and, with mouth open, drag the lower jaw beneath the surface in a scooping motion. One individual flew the six foot length of the pool six times before leaving. In one instance a *M. californicus* and a *Corynorhinus* were over the pool at the same time. On this occasion the lump-nosed bat flew more rapidly and drank only once. At Agua Caliente Spring these bats appeared 30 minutes after the canyon bats (*Pipistrellus*) and were fewer in

number. However, both were drinking from the pool. On one occasion six bats were simultaneously drinking from the pool; all behaved alike, fluttering slowly over the surface with heads bent forward drinking. Three of these six were captured, two were *Pipistrellus* and one a *M. californicus*.

I have records of occurrence for *M. californicus* in every month of the year. These bats are most frequently encountered from May until September (Fig. 2). There is a gradual increase in the number of bats in the spring and a gradual decrease in their number in the autumn, fewest bats being found in the winter months (November to February). Because only two nursery colonies, and unfortunately no winter colonies, were found, it is difficult to interpret the true picture of seasonal populations and activity.

Myotis californicus is relatively free of ectoparasites. Bats found roosting singly were usually not infested. Individuals obtained from the nursery colony at Hulbard's Grove harbored mites of the genus *Ichoronyssus*. The mites were on the dorsal surfaces of the wing membranes and numbered three or four per bat. Bats taken at Vallecito Stage Station had mites of the genus *Spinturnix* on the upper surfaces of the wing and interfemoral membranes. Other ectoparasites, such as fleas, ticks, lice, bedbugs, and flies, which are known to live on other kinds of bats, were not found.

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ACTIVITY, FOOD CONSUMPTION AND HOARDING IN HIBERNATORS

By Charles P. Lyman

In previous papers it has been emphasized that the phenomenon of hibernation is not precisely the same among all mammals and differs even among various families of rodents. For example, the electroencephalograms of "le spermophile" (probably *Citellus citellus*) and the woodchuck (*Marmota monax*) differ markedly in hibernation and during the process of arousal from that of the golden hamster (*Mesocricetus auratus*) (Kayser, Rohmer and Hiebel, 1951; Chatfield, Lyman and Purpura, 1951; Lyman and Chatfield, 1953). The relatively active electroencephalograms of the deeply hibernating ground squirrel and woodchuck reflect the behavior of these species, for they respond to strong stimuli with uncoordinated muscular movements. The deeply hibernating hamster, on the other hand, is totally inert until the process of arousal is well under way.

Another important difference concerns the nutritional requirements during the hibernating period. Most rodents that hibernate, including the woodchuck and the ground squirrel, become extremely fat before the period of dormancy and apparently live on this fat during hibernation (Kayser, 1950). In contrast, the golden hamster, at least in the laboratory, loses weight when exposed to cold and actually enters hibernation when quite lean (Lyman, 1948). Although *Citellus*

tridecemlineatus (Howell, 1938) and many other hibernators store some food, storage appears to be of paramount importance in the hamster, for it eats during its periodic arousals from the hibernating state and apparently cannot live throughout the hibernating period if there is no food available (Lyman and Leduc, 1953).

The experiments described below were designed to clarify these differences. The food and water intake and the activity of a series of hamsters and ground squirrels were measured when the animals were kept in a warm environment and compared with the same measurements when the animals were exposed to cold and when they hibernated.

During the course of the experiments it became apparent that hamsters which were denied food for storage did not hibernate as soon as control animals. Therefore, a second experiment was designed to elucidate this point.

MATERIALS AND METHODS

Experiment 1.—A series of nine male hamsters (*Mesocricetus auratus*) between 15 and 20 weeks of age was housed in activity cages equipped with exercise wheels. The rotating wheel of each cage was 36 cm. in diameter and 11.5 cm. wide, and the resting cage measured 38 cm. long by 23 cm. deep by 23 cm. high. The animals were fed ground Purina chow from non-spillable food cups, and water was supplied from non-spillable water containers. Food and water intake and the number of revolutions of the activity wheel were usually measured each day. If very small amounts of water were consumed daily, allowance was made for evaporation from the water container.

The animals were maintained under these conditions for five to nine weeks in the fall of the year in an animal stock room. The environmental temperature was 24 ± 2°C. and the animals were exposed to between eight and nine hours of light daily. At the end of this period the hamsters were moved into a cold room maintained at 5° ± 2°C., which was illuminated daily for eight hours. The measurements were continued under these conditions.

A second series of two female hamsters of 15 weeks of age and two female ground squirrels (*Citellus tridecemlineatus*) over three years of age was housed in individual cages of the same size as the previous experiment. The cages were suspended from springs, and balanced from below by a tambour at each corner. Any major movement of the animal in the cage depressed one or more of the tambours. This was recorded pneumatically by means of a tambour and a stylus on a slowly revolving smoked chart. Food and water intake were measured as in the first experiment, and the animals were exposed to the same environmental conditions. In all experiments, when an animal was observed to be hibernating, a small amount of fine shavings was placed on its back so that, if it moved enough to displace the shavings, this could be noted at the next observation.

Experiment 2.—In order to test the effect of hoarding on hibernation a series of six male and six female hamsters, 15 weeks old, was housed in individual cages supplied with ample shavings in the cold room (5° ± 2°C.). They were fed water *ad libitum* and ground Purina Chow in non-spillable food containers.

Under these conditions the animals were unable to store food, as is their invariable custom if supplied with pellets of compressed food. These animals were observed daily and the day on which they first hiberated was noted.

To provide a controlled comparison with the experimental animals, the records of 373 animals that had been observed during the last few years in this laboratory were used. The use of this large number of animals was employed because it sheds some light on the variations encountered in a large group of animals. These hamsters were housed under conditions identical with the experimental animals in the cold except that they were fed Purina laboratory chow checkers and hence could store their food.

RESULTS

The nine hamsters in the wheel-type activity cages consumed, in the warm room, an average of 7.8 gms. (Standard Deviation 1.7) of Purina Chow each day. Omitting one animal that spilled water in spite of all precautions, the water consumption averaged 11.1 cc. (S.D. 1.2) per day. The animals averaged 7335 revolutions (S.D. 1834) of the wheel each 24 hours. It was apparent that most of the activity took place at night, whether the animals had an exercise wheel or whether the motion of the cage was recorded. There was no clear evidence of regular periodic activity other than the diurnal cycle.

When moved to the cold room, the food intake of the hamsters invariably rose and averaged 12.9 gms. (S.D. 2.3). This rise is statistically highly significant according to the "t" test, for P is less than .01. The water intake rose to 16.3 cc. (S.D. 4.7) per day. This rise is also highly significant in spite of the fact that one animal showed a slight decrease in water intake (from 11.3 to 10.5 cc./day). The hamsters were no more active in the cold than in the warm room as measured by the activity wheels, averaging 7141 revolutions (S.D. 3029) per day. Furthermore, there was no evidence in the tambour records that the animals moved about in their cages to a greater extent when exposed to cold.

Although most of the hamsters provided with activity wheels were kept in the cold room for over a year, only one animal hibernated on and off for 54 days after being in the cold for 44 days. During this period it was observed to be awake on 21 different days and the longest period of continuous hibernation was three days. In contrast, the average period of hibernation, punctuated by brief waking periods, for 19 typical controls was 95.1 days (S.D. 21.7). Furthermore, most hamsters remain continually in the hibernating state for protracted periods, the longest recorded in this laboratory being 21 days.

There was no diminution of exercise or food and water intake in the days just prior to entering the hibernating state. On each awakening the animal ate, drank and ran on the exercise wheel. Considering only the 21 days that the animal was awake, it averaged 4207 revolutions of the wheel, 12.7 gms. of food, and 25 cc. of water per day. This animal averaged 11,646 revolutions of the wheel, 14.8 gms. of food and 21.9 cc. of water per day in the cold room before entering hibernation.

One of the hamsters maintained in the tambour-recording cages hibernated

after only 11 days exposure to cold, but the total hibernating period lasted only 18 days during ten days of which the animal was observed to be awake. The period in the cold room before hibernation took place was too short to give a reliable figure, but the food intake increased and the water intake decreased during the 11 days. There was no evidence that food and water intake or exercise decreased in the last few days just prior to hibernation. In the ten days the animal was awake during the hibernating period it averaged 8.4 gms. of food and 10 cc. of water per day. This compares with 8.1 gms. of food and 5.1 cc. of water per day in the eleven days before hibernation.

The hamster in the other tambour-recording cage adopted a peculiar storing habit which spoiled the records of food intake and caused the abandonment of records on this animal, but also led to Experiment 2 of this series. This hamster was able to obtain food from the unspillable food cup by forcing its muzzle into the ground dog chow. Upon lifting its head from the food cup, it removed the crumbs clinging to its vibrissae with its fore paws and transferred them to its cheek pouches. After it had obtained a satisfactory amount of food in this way, it carried it to a far corner of the cage and stored it in the manner observed in hamsters fed solid pellets of food. This animal hibernated on the 72nd day after exposure to cold.

Ground Squirrels.—In the 62 days of observation prior to exposure to cold, ground squirrel no. 1 averaged 7.0 gms. of food per day and 12.2 cc. of water. During this period its weight dropped from 266 gms. to 237 gms. Ground squirrel no. 2 averaged 10.9 gms. of food per day and 22.5 cc. of water, and its weight dropped only from 275 to 267 gms. Both animals were very fat at the start of the experiment.

In sharp contrast to the hamsters, the two ground squirrels hibernated within 24 hours after being exposed to cold. Ground squirrel no. 1 hibernated over a period of 62 days, at the end of which time the animal was moved to the warm room because of its emaciated condition. Of the 62 days, it was observed to have moved enough to displace the shavings on its back on 14 days and was active enough to cause movement of the cage for a total period of 171 hours, or 12 per cent of the time. During the time it was awake it ate a total of 16 gms. of food and drank 87 cc. of water. It lost 111 gms. body weight during the 62 days of the sojourn in the cold.

Ground squirrel no. 2 hibernated over a period of 120 days after which it was moved to the warm room. During this period it was observed to have lost the shavings from its back on 23 days and was active enough to move the cage for a total of 225 hours or 8 per cent of the time. During the time it was awake it ate a total of 6 gms. of food and drank no water. It lost 130 gms. body weight during the 120 days.

Storing Experiment.—The twelve hamsters that were moved to the cold room but not allowed to store food hibernated after an average period of 97.6 days (S.D. 20.4). The earliest hibernation occurred on the 54th day and the latest on the 114th day. The average time before entering hibernation was approximately the same for both sexes. Once in the hibernating state, the animals remained

in this condition, with the usual periodic awakening, for a period of about three months. Thus the length of the hibernating period, once started, was not curtailed.

Of the 252 control animals that entered hibernation the average time before the hibernating state occurred was 56.6 days (S.D. 33.2). The shortest period before hibernation occurred after moving to the cold room was three days and the longest was 218 days. On the other hand, 121 animals of the control groups died before entering the hibernating state. The average time when death occurred after moving to the cold room was 71.5 days (S.D. 67.2).

In a statistical comparison between the time of onset of hibernation in the 12 hamsters deprived of storing and the 252 controls that hibernated, P is less than .01. This highly significant difference shows that the ability to store food has a profound effect on the occurrence of hibernation. On the other hand, the data on the other 121 control animals show that in a large population of hamsters in the laboratory, some animals will live in the cold and eventually die without entering hibernation. Therefore it may be more accurate to include the animals that died in the cold with the other control animals. If the total span of life in the cold of these animals is averaged with the total time in the cold before hibernation in other controls, one obtains a figure of 61.4 days (S.D. 47.4). When this figure is compared with the 97.6 days for the experimental animals the difference between the two figures is still found to be highly significant according to the Fisher "t" test ($P < .01$). In other words, the possibility that the marked delay in the onset of hibernation in the non-storing hamsters is due to chance is less than one in 100.

DISCUSSION

The increased food and water intake of hamsters when exposed to cold is typical of mammals that do not hibernate, and is to be expected with the increase of metabolic rate. That the metabolic rate does increase in hamsters when exposed to cold can be seen by comparing the figure 1014 cc. O_2/K/hr. for golden hamsters at 29.6° (Kayser, 1940) or 930 cc. O_2/K/hr. at 30–34°C. (Adolph and Lawrow, 1951) with 2877 cc. O_2/K/hr. at 5°C. (Lyman, 1948). These reactions are in sharp contrast to the almost immediate hibernation and cessation of eating and drinking that took place when the two ground squirrels were exposed to cold. Although ground squirrels do not invariably hibernate within 24 hours after exposure to cold, as Johnson (1930) has amply demonstrated, still the onset of hibernation is usually quite rapid. On the other hand, of the more than 1000 hamsters exposed to cold in this laboratory, the shortest recorded time before hibernation occurred was three days, with most animals far exceeding this figure.

The hibernating phase of the two hamsters recorded here cannot be regarded as typical, because the period was curtailed and the animals awoke more often than is normal. However all indications are that golden hamsters keep up high food and water intake and remain active up to the time they hibernate. Furthermore, the data emphasize that the hamsters will consume considerable nourish-

ment each time they wake from hibernation. Although observations in the wild on the golden hamster are lacking, the European hamster is known to be an inveterate hoarder of food, so much so that the German word "hamster" means to hoard or store in anticipation of need. It is highly probable that hamsters do not have access to water when they are holed up for the winter, and it is reasonable to suspect that metabolic water and water from the stored food are their only sources. The data indicate, however, that the animals will drink a considerable quantity if water is available.

The second experiment demonstrates clearly that the ability to store food has a profound effect on the time of onset of hibernation. Waddell (1951) has shown that noxious conditions such as illuminating the food bin will increase the storage of food by hamsters, and McCleary and Morgan (1946) have demonstrated similar reactions in the rat when it is exposed to cold. The denial of the ability to hoard when stimulated to do so by cold must upset the behavioral pattern of the animal so that the onset of hibernation is delayed, or, in the case of one animal in the cage on tambours, the period of hibernation abnormally shortened. This takes place in spite of the fact that there is obviously ample food obtainable at all times from the food containers.

Again in contrast to the hamsters, the ground squirrels hardly touched food or water while they were exposed to cold and the fast is reflected in the great loss of body weight. This loss of weight bears out the recent work of Kayser (1952) with the European ground squirrel (*Citellus citellus*). He was able to show that the large weight losses observed in animals during the hibernating period were not due to loss of weight during hibernation, but were directly correlated with the amount of time the animals were awake during that period, for the process of arousal and the awake condition consumed a great deal of energy. Thus in ground squirrel no. 1, which was awake a much larger proportion of the time, the weight loss was much faster (1.8 gms./day) than in ground squirrel no. 2 (1.1 gms./day).

Although laboratory experiments can not completely clarify the conditions that occur in the wild, it seems justifiable to draw from these results a sharp distinction between the preparation for hibernation in animals such as the ground squirrel on the one hand, and the hamster on the other. Under stimuli which have yet to be elucidated, the former animals grow extremely fat in the period previous to hibernation. Exposure to cold is then apt to cause almost immediate hiberation. If hibernation does not occur at once, denial of food will hasten it (Johnson, 1930, confirmed in these laboratories). Although the ground squirrel stores food (Howell, 1938), it is apparent that it can survive repeated awakenings with practically no nourishment by utilizing its stored fat. From all indications the woodchuck (*Marmota monax*) is very similar to the ground squirrel, for it becomes extremely obese by fall, and does not even store food in its burrow (Merriam, 1884).

The hamster, on the other hand, apparently makes no physiological preparation for hibernation until actually exposed to cold. Under the stimulus of cold exposure, it stores food and loses weight. If food storage is denied, hibernation

is delayed. Food storage is essential for the maintenance of the hamster during the hibernating period, for the energy necessary for the periodic awakening is soon exhausted if the stored food is removed and the animal cannot eat during the periods of activity (Lyman and Leduc, 1953). Unpublished experiments in these laboratories have conclusively shown that, in contrast to the ground squirrel, denial of food or water will never cause hibernation in the hamster, which is precisely what might be expected in view of the importance of stored food. Thus the golden hamster is provided with a check against hibernation before food has been stored, which, under natural conditions, must protect the animal against starvation during the hibernating period.

How the lack of food hoarding can delay hibernation is a problem in itself. Indications are that it is not the only psychic factor which can influence the onset of hibernation, for of the nine animals with activity wheels only one hibernated for a very short period, though all were exposed to cold for over a year. Possibly exercise on activity wheels itself may have an effect on the onset of hibernation. In any event, it is evident that a behavior pattern such as storing can have a profound effect on the onset of hibernation in the hamster. That behavior must be considered along with all the physiological factors when attempting to resolve the cause of hibernation certainly compounds the complexity of the problem.

SUMMARY

In a series of experiments with golden hamsters (*Mesocricetus auratus*) and thirteen-lined ground squirrels (*Citellus tridecemlineatus*) it was found that the former animals did not hibernate at once, but increased their food and water intake when moved to a cold environment, while the amount of exercise taken remained unchanged. In the two hamsters that eventually hibernated there was no decrease of eating, drinking or exercise up to the time of hibernation. The hamsters ate and drank considerable quantities and exercised to some extent on each awakening from hibernation. Hamsters that were prevented from hoarding food showed a marked delay in entering hibernation.

In contrast, the ground squirrels hibernated within 24 hours after exposure to cold. In their periodic wakenings the ground squirrels ate and drank almost nothing and in consequence lost much of their stored fat.

It is concluded that the ground squirrel is stimulated in some unknown way to prepare for hibernation by becoming extremely obese. Exposure to cold brings on hibernation quickly and the animal lives almost exclusively on his stored fat during the hibernating period. The golden hamster, on the other hand, does not fatten prior to hibernation, but is stimulated by cold to store food. This food is used during the periodic arousals in the hibernating period, and without the store the animal would perish. Denial of the ability to hoard causes a delay in the onset of hibernation and thus must provide the animal with a check against premature hibernation that would result in starvation.

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METABOLIC DIFFERENCES BETWEEN THREE STRAINS OF *PEROMYSCUS MANICULATUS*

By S. F. Cook and J. P. Hannon

The existence of metabolic differences between races of humans or animals has been subjected to two divergent explanations. According to the first of these theories, genetic differences are possible in the sense that one racial strain of the same species may show a higher or lower standard energy production than another irrespective of any immediate environmental considerations. According to the other concept, all quantitative variation in metabolic rate is a reflection of the influence of the local environment upon the individual, and through the individual the group. We have attempted to test these hypotheses in so far as one mammalian species is concerned by selecting representatives of three ecological types, or races, subjecting them to a reasonable period of adaptation to a common environment, and then measuring the average standard metabolism.

The species is *Peromyscus maniculatus*, the deer mouse, of enormous range and cosmopolitan habit. The three localities from which the specimens were taken were respectively Berkeley, Tule Lake, and White Mountain, all within the state of California. The first principle guiding the selection was geographical remoteness, for each locality is separated from both the others by several hundred miles. It could therefore be presumed that any differences in standard metabolism would be referable to a fixed and stable population. Indeed, that each population represented a distinct strain appeared probable by virtue of deviations in length and color of the fur and the relative shapes and sizes of the ears, tail and head.

The second principle guiding selection of locality pertained to the quantitative differences in two critical environmental factors, temperature and altitude, both of which might conceivably alter individual or group metabolic rates. The Berkeley environment extends from sea level to an altitude of 1,500 feet and the annual temperature range is from approximately 30 to 60°F. We have therefore no serious stress exerted upon the animals with reference to either ambient temperature or oxygen pressure. At Tule Lake the altitude is very close to 4,000 feet. Thus, even though the oxygen pressure is somewhat less than at Berkeley, the difference is not sufficient to constitute a critical factor from the physiological point of view. At the same time, the annual temperature range is much greater. In the winter, the thermometer drops frequently below 0°F., whereas in the summer the temperature approximates that of Berkeley. A temperature stress with no appreciable deficiency in oxygen is thus present. The third group was taken from an elevation of 12,500 to 13,000 feet at the crest of the White Mountain Range, just east of Bishop in the Owens Valley. The chronic hypoxia due to high elevation is severe while the temperature throughout most of the year ranges from near 40 to below 0°F. A very great stress due to both causes is hence unavoidable.

METHODS

The mice were caught with simple can traps. A total of nine females and 18 males were caught in the Berkeley area, 20 females and 14 males near Tule

Lake, and 11 females and 21 males at White Mountain. After capture the mice were brought into the laboratory in Berkeley and established in regular laboratory cages. All the animals received the same food, the so-called "green diet" used successfully with laboratory rats and mice by the Institute of Experimental Biology on this campus. This diet was to all appearances well-suited to *Peromyscus* since all the specimens remained in evident good health. All the mice, including those caught in the close vicinity, were subjected to an adaptation period of two months. It was felt that insofar as the individual animals were concerned this interval was sufficient for the completion of adjustments both to temperature and altitude. After the lapse of sixty days measurements of metabolic rate were begun.

Oxygen consumption was used as an index to metabolic rate. Measurements were made by means of a modification of the manometric technique as previously described by Cook, *et al.* (1950). Each unit of the system consists of a manometer filled with Brodie solution in connection with an air-tight respiration chamber having a volume of approximately 14 liters. Oxygen uptake is measured through pressure changes which in turn are converted to terms of volume by means of the customary pressure-volume-temperature formula. Within the chamber, carbon dioxide and water vapor are absorbed by soda-lime and by saturated potassium hydroxide. To compensate for the loss incurred through respiration, oxygen is introduced into the chamber at two-hour intervals, and therefore readings could be continued over as long a period as desired. In practice it is found that periods of six hours in length are the most satisfactory. Since the animals are withdrawn from their feed only just prior to placing them in the chambers, a six-hour period encompasses the interval during which they become post-absorptive. If on the other hand the mice are prevented from eating for six hours prior to the experiment and are then kept from food for a further six hours they will have reached a level of definite starvation. Either procedure conduces to some metabolic variation. We have considered, however, that less harm is done the animals and less variation introduced into the data if the first method is consistently adhered to.

Unavoidably in dealing with whole-animal metabolism as described, the degree of physical activity constitutes the principal source of random error. If we are to conserve the semblance of standard metabolism (since, of course, with such organisms we cannot achieve a clinically basal condition), the use of an anaesthetic, or other chemical agent is prohibited. On the other hand, it is legitimate to restrict the scope of muscular action by any means which does not operate upon the biochemical level. We have, therefore, uniformly placed each mouse inside a small cage made of fine gauge wire screen prior to introduction into the respiration chamber. The effect is to restrict wide movements without imposing uncomfortable constriction.

Despite all precautions, the oxygen consumption of individual mice shows wide variation. Hence the attempt was made to utilize sufficient animals for long enough periods to nullify random deviation, or at least to bring it within reasonable bounds from the statistical point of view. As indicated previously,

TABLE 1.—*Average values for body weight and oxygen consumption of three strains of Peromyscus; Berkeley, Tule Lake; and White Mountain. The sexes are shown separately. For purposes of comparison the White Mountain mice are assigned the arbitrary value of 100 per cent and the values for the other two strains are equated to the same scale. The values for t refer to the significance of the difference between the means for Tule Lake or Berkeley on the one hand and White Mountain on the other.*

	Males			Females		
	White Mt.	Tule Lake	Berkeley	White Mt.	Tule Lake	Berkeley
No. Mice	21	14	18	11	20	9
Body weight						
Mean, grams	26.4	26.8	25.8	25.2	25.1	21.4
S.D.	±2.20	±2.81	±2.76	±1.89	±2.46	±1.43
S.E.	±0.48	±0.75	±0.65	±0.57	±0.55	±0.48
t	—	0.45	0.74	—	0.13	4.94
Relative value in per cent	100	101.5	97.8	100	99.5	84.9
O_2 Consumption, per animal per hour						
Mean, ml	64.8	75.6	73.2	64.6	72.8	71.1
S.D.	±6.01	±7.26	±5.56	±5.27	±4.83	±4.72
S.E.	±1.31	±1.94	±1.31	±1.59	±1.08	±1.57
t	—	4.44	4.52	—	3.15	2.90
Relative value in per cent	100	116.7	113.0	100	112.7	110.1
O_2 Consumption, per gram per hour						
Mean, ml	2.49	2.85	2.89	2.58	2.95	3.33
S.D.	±0.142	±0.169	±0.259	±0.129	±0.228	±0.153
S.E.	±0.031	±0.045	±0.061	±0.039	±0.051	±0.051
t	—	6.53	5.81	—	5.69	11.19
Relative value in per cent	100	114.5	116.2	100	114.3	129.2

the minimum number of animals of any one category which we were able to secure was nine and the maximum was twenty. The oxygen consumption of each animal was measured (throughout six-hour periods) for a minimum of twelve hours and in some cases for as many as thirty. The *average* hourly value was then computed for each animal, thus reducing materially the hour-to-hour fluctuations in respiration which inevitably characterize any method permitting normal freedom of action to the individual mouse. The mean value for the category (by sex and locality) was finally calculated. From Table 1 it will be noted that the standard error of estimate shown by the method described was of the order of from 2 to 4 per cent of the corresponding mean. Without using a prohibitive number of animals it would be difficult to reduce the random variation much below the level indicated.

Temperature control during measurement was secured by the use of a thermoregulated heater which kept the air of the laboratory very close to 24°C. Due to the heat given off by the mouse the temperature inside the respiration chamber

approximated 26°C. As indicated by thermometers the interior temperature did not vary more than plus or minus one half degree. Fluctuation between these limits could have no appreciable effect upon the metabolic rate of the animal, and meanwhile the manometric changes induced thereby, together with those referable to shifts in barometric pressure were corrected by the thermobarometer, as in the customary Warburg technique.

RESULTS

In Table 1 are given for each group of animals the mean weight observed throughout the entire period of measurement, the mean oxygen consumption per animal per hour and the mean oxygen consumption per gram weight per hour.

The data in detail showed, as would be anticipated, a tendency for the total oxygen consumption to increase with size of animal and for the oxygen consumption per unit weight to decrease correspondingly. It might therefore have been preferable to express metabolic rates as a function of the body surface, or as a power function of the body weight as has been recommended by Kleiber (1932) and other investigators. On the other hand with one exception the average weights of all the groups of mice were very close to each other and the spread of individual weights within each group was very narrow, as may be noted from the standard deviations shown in the table. Indeed, preliminary calculations made it clear that very little would be gained by an attempt to eliminate weight differences by mathematical procedures.

The mean values for oxygen consumption as seen in Table 1 are in agreement with the general range of values shown by measurements on wild mice of comparable weight as reported by Morrison (1948) and Pearson (1948). However, of special importance to the present study are the distinct differences of metabolic rate seen in the three populations when measured under standard conditions.

The populations from Tule Lake and Berkeley show a mean oxygen consumption higher than that found among the White Mountain mice. The differences are highly significant since the t values, or the Critical Ratios of the means, range from 3.1 to 6.5 (Table 1). At the same time, there is no significant difference in weight between populations of a given sex with the exception of the females from Berkeley. The latter group, to be sure, differs widely in metabolic rate from the females from White Mountain but the statistical significance of this difference loses its force since the Berkeley females are considerably smaller than those from White Mountain, and one might easily attribute the metabolic difference to the disparity in size. That the size here is the responsible factor is borne out by the fact that the oxygen consumption per unit weight of the Berkeley females is also much in excess of that of the Tule Lake females.

With respect to the six groups as a whole, however, the data in Table 1 indicate that when expressed on a percentage, as well as an absolute, basis, the White Mountain mice tend to show a lower metabolic rate than those from either of the other two localities. Thus, when we set the mean O_2 consumption per animal per hour, or per gram weight per hour, of the White Mountain mice as equivalent to 100 per cent, the corresponding values for all other groups are clearly greater

than 100 per cent. The significance of these differences is demonstrated by the uniformly high values of t, or the Critical Ratio of the means.

DISCUSSION

That metabolism may vary among species of small mammals is indicated by the work of Morrison (1948), Hatfield (1939), Benedict and Lee (1936), Lee (1939, 1940) and Benedict and Petrik (1930). Pearson (1947, 1948), having noted that between species of the same weight range there may be widely varying rates of metabolism, took the view that the metabolic rate is not closely associated with taxonomic, ecological or anatomical factors. Such interspecific variations have, however, been attributed to the characteristics of the diet by Wu and Chen (1929) and to genetic influence on body size by Kleiber and Cole (1950).

The present study, which uses statistically adequate numbers of mice, indicates clearly that metabolic variations may exist within one species when the latter is segregated according to geographical races, even though the latter fall within the same weight range. The lower metabolic rate found in White Mountain mice, as pointed out previously, cannot be ascribed to difference in weight between the specimens from this race and those from the races inhabiting the areas of Berkeley or Tule Lake. Furthermore the racial distinction persists even after all three groups have been maintained under conditions as nearly identical as possible for a period exceeding two months.

Several factors might be invoked as explanation for the lower standard metabolism of the White Mountain population. One of these might pertain to the average, or over-all level of physical activity displayed by the three groups. The influence on metabolism of consistent variation in activity during the determinations of oxygen consumption was emphasized by Benedict and Riddle (1927) with steers and by Benedict and MacLeod (1929) with rats. These investigators found that a minor degree of activity is in general without effect upon metabolism, but repeated, intermittent activity may induce an average increase of 15 to 20 per cent in metabolic level. More recently Morrison (1948) has demonstrated that a difference of 70 to 90 per cent exists between the minimum and maximum oxygen consumption of *Peromyscus*. The minimum occurs during the daylight hours, during repose, and the maximum at night, when the animals normally become most active. In our experiments the random fluctuations on oxygen consumption induced by rapid, casual and unpredictable changes in physical activity were cancelled out by the use of long exposure periods in the respiration chamber, restriction of movement during the experiment, and the employment of a reasonably large number of individual mice. Secular, or diurnal, shifts in exercise and hence in metabolic rate were obviated by measuring the gas exchange always during the same six-hour period, from 9 AM to 3 PM. With respect to the three strains of *Peromyscus*, no systematic and sustained difference in activity level could be detected.

In the case of any study with wild animals the ages of the individuals are not known. That the basal metabolism of humans decreases with age has been pointed

out by many investigators, for instance Harris and Benedict (1919). A similar fall in metabolism with advancing age has been noted with rats by Mitchell and Carman (1926) and Davis (1937). Despite a contrary opinion expressed by Benedict and MacLeod (1929), the view has been generally accepted that there is a reduction in metabolism as the animal grows older. Whether the age factor was of significance in this investigation of *Peromyscus* cannot be stated with certainty, for the possibility is present that the population samples may have been drawn in such a way as to show unintentional bias with respect to age. On the other hand, no such effect is readily detectable, and variation due to this factor was minimized by employing animals which were clearly adults as determined by hair color and body weight.

Other potentially disturbing factors are season, environmental temperature at the time of measurement, and sex. These can be ruled out since the temperature surrounding all the groups was identical from the time that they were brought into the laboratory, since the oxygen consumptions were all determined at the same time of year, and since the sexes were segregated as shown in the tables.

There remain, as possible determining factors, the features of the environments from which the various animals were drawn. When these are examined there is found one strikingly distinct environmental condition which pertains specifically to the group native to the White Mountain area. All the White Mountain animals used in this study were trapped at an altitude of from 12,500 to 13,000 feet, indicating that in their native state they were the only group of the three investigated which had been subjected to conditions of hypoxia. The central questions which arise in this connection are whether the low metabolic rate demonstrated by this race at low altitude is characteristic of the race at high altitude, and if the low metabolism is an adaptation calculated to increase resistance to reduced oxygen tensions. It must be conceded that no categorical answer can be given at present to these questions.

Numerous investigations have been carried out, relative to the possible effect of hypoxia on the over-all oxygen consumption of mammals. Many of the available reports indicate that the oxygen consumption remains unchanged during adaptation. Recent evidence supporting this point of view has been brought out by Lipin and Whitehorn (1950), Houston (1946), Houston and Riley (1947) and McCrery *et al.* (1943). On the other hand Blood *et al.* (1948), Kottke *et al.* (1948) and Sundstroem and Michaels (1942) have shown that one of the first responses made by mammals when they are subjected to hypoxic conditions is a reduction of body temperature and respiratory gas exchange. The problem, therefore, must be regarded as still awaiting final solution. In the present instance the data clearly indicate that White Mountain *Peromyscus maniculatus*, when studied at low altitude, show a low metabolic rate in comparison with other strains of the same species.

We can furnish no unequivocal clue to the physiological mechanism which is responsible for the observed low metabolic level. Nevertheless at least two reasonable hypotheses may be mentioned.

In 1932 Kleiber discussed what he called the "specific insulation" of an animal, by which he referred to the length and thickness of the hair in the pelage. The White Mountain mice have fur which is definitely longer and thicker than that characterizing the Tule Lake or the Berkeley animals. The heat loss of this race is consequently less than that of the other two races under comparable conditions of cold and hence they would require less oxygen to maintain body temperature. This feature might be beneficial under the extreme winter conditions at the summit of the White Mountain range. That this is a reasonable supposition would be implied by the work of Sumner (1932) who cited many cases in which there is a natural selection of races of *Peromyscus* by virtue of a distinctive pelage closely adapted to the native environment.

In opposition to this theory, however, stands the fact that the mice from Tule Lake showed the same metabolic level as those from Berkeley, but a higher level than those from White Mountain. The winter temperatures at Tule Lake are of the same general degree of severity as those at White Mountain although the season of cold weather does not last as long. Hence to ascribe the metabolic difference to the temperature factor leads to a serious inconsistency.

The alternative suggestion is that altitude is the critical factor. If so then we must assume that the low oxygen tension characterizing the racial environment has in some manner induced a reduction of metabolic rate and that the difference between strains reflects a biochemical and tissue modification. Concerning the nature of such a modification we have as yet no information.

SUMMARY

The standard metabolism of three races of *Peromyscus maniculatus* was measured by means of the manometric method. The three strains were taken from localities that represent widely varying environments: (1) Berkeley, California, at sea level and with moderate temperature, (2) Tule Lake, California at 4,000 feet and with low average temperature, (3) White Mountain, California, at 12,500 feet and with low average temperature.

The mice native to high altitude, when measured at sea level, have a lower standard metabolism than both groups native to low altitude. It is possible that there is a genetic difference involved. Such a difference might be manifested in the insulation capacity of the pelage or alternatively might be ascribed to the influence of hypoxia on the tissue metabolism of the White Mountain mice.

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OLDFIELD MICE, *PEROMYSCUS POLIONOTUS*, OF SOUTH CAROLINA

By Albert Schwartz

Bangs (1898*a*: 203) first commented upon the probable occurrence of oldfield mice (*Peromyscus polionotus*) in South Carolina. It was not, however, until 1939 that Bangs' assumption was proven correct. At that time, Coleman (1939: 505–506) reported the taking of three specimens of oldfield mice at three separate localities in South Carolina, *ie.*, near Abbeville, River Falls near Greenville, and near St. Matthews. Of these three localities, the first two are within the Piedmont physiographic province, while the latter is in the Atlantic Coastal Plain. Later Coleman (1948: 294) recorded the taking of a fourth South Carolinian specimen 4½ miles east of the Savannah River and about 12 miles west of Allendale; this is again a Coastal Plain locality.

Professor Coleman, pursuant of his work on the mammals of South Carolina, has continued collecting specimens of *P. polionotus* from South Carolina and Georgia; certain differences in pelage color between Georgia and South Carolina material were noted by him, and his entire collection of these mice was loaned to the writer for study. I wish to extend my sincere thanks to Robert H. Coleman not only for being allowed to study his series of specimens but also for his granting me permission to describe the new forms which have been discovered in this lot of material. Specimens have also been borrowed from several institutions, and the writer is grateful for the courtesies extended him in this regard by the following: J. Kenneth Doutt and Dana P. Snyder, Carnegie Museum; Colin C. Sanborn, Chicago Natural History Museum; Miss Barbara Lawrence and Charles P. Lyman, Museum of Comparative Zoology; Stanley P. Young and Miss Viola S. Schantz, United States Fish and Wildlife Service, Biological Surveys Collection; H. B. Sherman, University of Florida; Eugene P. Odum and L. B. Davenport, Jr., University of Georgia.

In order to achieve a better understanding of the variation in the South Carolinian material under consideration, the writer has examined specimens of *P. polionotus* from Georgia, Florida, and Alabama, as well as South Carolina. These specimens represent all the known races of *polionotus*. *P. polionotus* occurs in the southeastern portion of the United States; the relationships of this species are apparently with *P. maniculatus* as has been pointed out by Bangs (1898*a*: 201) and by Osgood (1909), who included *polionotus* in his *maniculatus* group.

The races of *P. polionotus* fall into two rather definite categories: 1) a series of forms, on the east coast of the Florida Peninsula (*phasma*, *decoloratus* and *niveiventris*), and on the Gulf Coast of Florida (*leucocephalus* and *peninsularis*) that are exclusively beach inhabitants and that are quite pale in coloration; 2) a series of forms (*polionotus*, *albifrons*, and *rhoadsi*) that primarily occupy old fields and occur some distance from beaches. Although members of this second group may occur on the coast, they are predominantly old field inhabitants.

This second lot of races is rather darker in color; *niveiventris* of the beach form most resembles *rhoadsi* of the oldfield forms in coloration.

Chapman (1893: 340) described *Peromyscus niveiventris subgriseus* (type locality: Gainesvelle, Alachua County, Florida). This form was raised to specific status by Bangs (1898*a*: 200) who stated that "neither do I know of any point where its range meets that of *P. niveiventris*, and even if some such place does exist, the two species are so different that intergradation is out of the question." At the same time, Bangs described two new forms of *P. subgriseus*: *P. s. rhoadsi* (type locality: head of Anclote River, Hillsborough County, Florida) and *P. s. arenarius* (type locality: Hursman's Lake (Savannah River), near Bascom, Scrivin [*sic*] County, Georgia). The name of the latter form was later (1898*b*: 214) changed to *P. s. baliolus* because of the preoccupation of *arenarius*. Osgood (*op. cit.*: 104–105) employed Wagner's *Mus polionotus* as a name for these small mice; Chapman's *subgriseus* had thus been antedated by fifty years. Also, Osgood made *polionotus* and *niveiventris* conspecific, and those subspecific names formerly associated with both *niveiventris* and *subgriseus* were relegated to subspecific ranking under *polionotus*. At the same time, Osgood placed *subgriseus* and *baliolus* in synonomy with *P. p. polionotus*.

Examination of 59 specimens of *Peromyscus polionotus* from north-central Florida, including 24 specimens from the immediate vicinity of Gainesville, convinces the writer that *P. p. subgriseus* Chapman should be removed from the synonomy of *P. p. polionotus* Wagner. The type locality of the nominate race is Georgia, according to Osgood; likewise the type locality of Bangs' *baliolus* (a synonym of *polionotus*) is Hursman's Lake, Georgia, within the range of the race *polionotus* as understood at present. In this regard it is of interest to note that Bangs, in his description of *arenarius* (= *baliolus*), comments (*loc. cit.*): "*P. subgriseus arenarius* is readily distinguished from *P. subgriseus typicus* by its much darker, browner coloring. In *P. arenarius* the upper half of the tail is black, while in *P. subgriseus typicus* the tail has a narrow line of dark gray along the upper surface. The ear is also nearly black, while in *P. subgriseus typicus* it is gray." Differences in pelage coloration as noted by Bangs appear to be quite constant; material from north-central Florida agrees well with the diagnosis of *subgriseus* and separates this race from *polionotus*. The tail likewise is generally lighter and the dorsal stripe is usually gray and narrow in *subgriseus* and black or dark brown and wide in *polionotus*. The coloration of the ears seems too variable to be used as a diagnostic character between these two subspecies.

Aside from the paler coloration of *subgriseus* (between Avellaneous and Vinaceous Buff on the side in fresh pelage, darkening to Buffy Brown dorsally) this race, as known by topotypes from Gainesville, Florida, differs from *polionotus* in smaller average size and shorter tail. Cranially, *subgriseus* averages smaller than *polionotus* in measurements of greatest length, basilar length, zygomatic breadth, length of nasals, palatilar length, length of palatine slits, and diastema. From *rhoadsi*, the race with which *subgriseus* intergrades to the south, *subgriseus* differs in slightly smaller size and more gray (less brown) coloration; cranially, *subgriseus* averages smaller than *rhoadsi* in measurements of greatest length, basilar length, zygomatic breadth, length of nasals, and diastema. Although no

intergrades between *subgriseus* and *albifrons* have been observed, *subgriseus* differs from this more western race in being smaller and having a shorter tail, as well as being more gray in coloration. The cranial differences between *subgriseus* and *albifrons* are the same as those noted above in comparison of *subgriseus* and *rhoadsi*, and *subgriseus* also averages smaller in palatilar length. *P. p. subgriseus* is of course much darker than all the beach inhabiting members of the species and is thus easily differentiated from them on the basis of color. It seems from the above that the name *subgriseus* should be applied to that population of *Peromyscus polionotus* in north and central Florida which differs from adjacent populations in its smaller overall size and paler coloration. Localities from which material here assigned to *subgriseus* have been examined have been plotted (Fig. 1). Eleven adults from Newberry, Alachua County, Florida, differ from

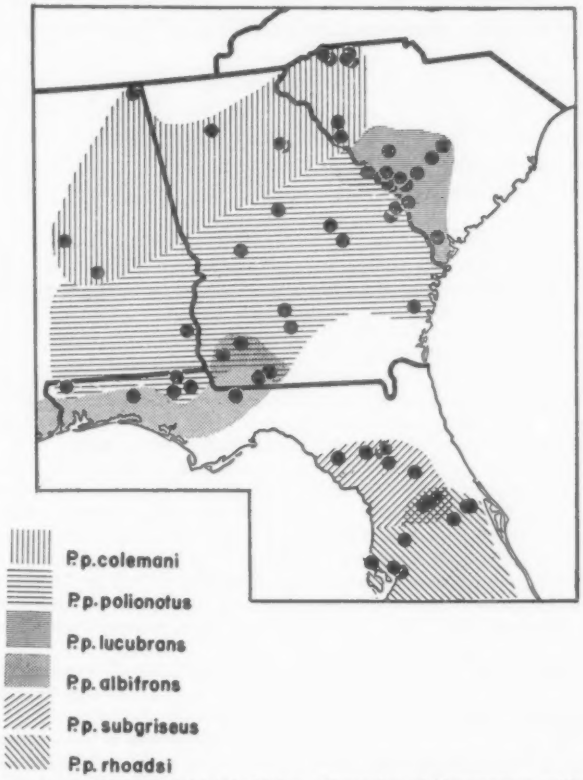

FIG. 1.—Ranges of the old field inhabiting subspecies of *Peromyscus polionotus* in the southeastern United States; the ranges of the beach inhabiting forms (*leucocephalus*, *peninsularis*, *phasma*, *decoloratus* and *niveiventris*) have not been shown. Solid circles represent localities from which specimens have been examined. Several localities in the immediate vicinity of Gainesville, Florida, have not been plotted. The range of *P. p. rhoadsi* extends to the south on the Florida Peninsula farther than indicated here.

topotypical *subgriseus* in greater total length and length of tail. These individuals average close to *polionotus* from Screven County, Georgia, in external measurements; the skulls of all but two of this series are missing and consequently no adequate comparison of cranial measurements can be made. Osgood (*op. cit*: 104) gives averages of external measurements for five adults from Gainesville which are considerably greater than those that the present study indicates as characteristic of this race. Presumably Osgood's five adults were exceptionally large individuals. In all specimens presently assigned to *subgriseus*, the pale coloration is at once obvious.

Study of the material at hand from South Carolina shows that the population of *P. polionotus* in South Carolina may be divided into two subspecies, both of which are undescribed. Since one of these new races occurs in Georgia, the type locality of Wagner's *Mus polionotus*, it seems advisable at this time to restrict the type locality of *Peromyscus polionotus polionotus* Wagner to Screven County, Georgia.

The two new races may be described as follows. All measurements are in millimeters and all capitalized color names are from Ridgway (1912). There are no significant differences between means of males and females from the same locality and consequently both sexes have been used in computing averages of external and cranial measurements.

Peromyscus polionotus lucubrans, subsp. nov.

Holotype.—Adult male, skin and skull, no. 1775, collection of Robert H. Coleman; from 4½ miles east of Savannah River on U. S. highway 301, Allendale County, South Carolina; taken by Robert H. Coleman, December, 21, 1941.

Distribution.—Known only from South Carolina, north and east of the Savannah River and south and east of the Piedmont (Fig. 1).

Diagnosis.—Similar to *P. p. polionotus* from Georgia and Alabama, but averaging somewhat smaller in certain measurements. Differs from *P. p. albifrons* and *P. p. rhoadsi*, as well as the beach-inhabiting races, by its darker coloration. Similar to *P. p. subgriseus* in coloration, but less gray and generally with mid-dorsal band better defined.

Description of type.—External measurements: total length, 119; tail 48; hind foot, 16.5; ear from notch, 12. Weight, 14.1 grams. Testes, 7 x 5. Cranial measurements: greatest length, 22.3; basilar length, —; zygomatic breadth, 12.7; interorbital constriction, 3.9; length of nasals, 8.7; palatilar length, 8.6; palatine slits, 4.1; diastema, 5.4; alveolar length of upper molar tooth row, 3.2. Color: sides, Avellaneous grading to a dorsal band of Cinnamon-Brown, moderately well defined, beginning on forehead and extending to rump. Cheeks and nose, Pinkish Cinnamon. Ears, Wood Brown, finely edged with whitish. Venter, white, hairs gray basally. Fore and hind feet, white. Tail, bicolor, Cinnamon-Drab dorsally, white ventrally. Dorsal and ventral coloration of body sharply distinct.

Characters and comparisons.—*P. p. lucubrans* differs from the other named forms of old-field and beach mice primarily in its coloration. From the races *phasma, decoloratus, niveiventris, leucocephalus* and *peninsularis, lucubrans* differs in its darker (more brownish) coloration. It is most closely approached in color by specimens of *niveiventris*, but this beach inhabiting form is, geographically, far removed and is still paler than specimens of *lucubrans*. Compared with specimens of *polionotus, subgriseus, rhoadsi*, and *albifrons*, *P. p. lucubrans* resembles *subgriseus* most closely in color, but differs from that form in being larger and having a longer tail. It is separated from the range of *subgriseus* by the intervening territory occupied by *polionotus*. *P. p. lucubrans* differs from *polionotus* in paler coloration and smaller average size, from *albifrons* in darker coloration and smaller average

TABLE 1.—*External measurements and cranial measurements (means and observed ranges) of six subspecies of P. polionotus comprising the oldfield mouse group*

Subspecies	No. of Specimens	Total Length	Tail	Hind Foot	Greatest Length	Basilar Length	Zygomatic Breadth	Nasals	Palatilar Length	Palatine Slits	Diastema	Upper Molar Row
P. p. polionotus (Screven Co., Ga.)	16 ♂♂	125	47	16	22.5	16.7	11.9	8.7	9.0	4.1	5.6	3.2
	11 ♀♀	(116–137)	(40–57)	(16–18)	(21.6–23.8)	(15.8–17.7)	(11.0–12.5)	(8.0–9.6)	(8.4–9.7)	(3.7–4.7)	(4.9–6.3)	(3.0–3.7)
P. p. colemani (S. C. and Ga.)	7 ♂♂	122	45	16	22.3	16.6	12.1	8.6	8.6	4.1	5.6	3.2
	4 ♀♀	(112–137)	(40–54)	(15–18)	(21.7–22.9)	(16.0–17.5)	(11.2–13.9)	(8.1–9.4)	(8.4–9.0)	(4.0–4.3)	(5.2–6.1)	(3.0–3.3)
P. p. lucubrans (S. C.)	9 ♂♂	121	46	16	22.2	16.6	11.9	8.7	8.7	4.0	5.5	3.2
	16 ♀♀	(114–134)	(44–51)	(15–18)	(21.3–22.9)	(15.8–17.5)	(11.4–12.7)	(8.1–9.4)	(8.3–9.4)	(3.6–4.6)	(5.3–5.9)	(3.0–3.4)
P. p. albifrons (Gadsden & Walton cos., Fla.)	4 ♂♂	128	47	17	22.7	17.1	12.1	8.8	8.8	4.0	5.4	3.2
	10 ♀♀	(120–136)	(44–52)	(17–18)	(22.1–23.5)	(16.2–17.8)	(11.8–12.7)	(7.7–8.8)	(8.3–9.2)	(3.7–4.4)	(4.5–6.1)	(2.9–3.4)
P. p. subgriseus (Alachua Co., Fla.)	11 ♂♂	118	43	16	21.8	16.2	11.4	8.1	8.5	3.9	5.3	3.1
	8 ♀♀	(111–129)	(38–49)	(15–17)	(21.0–23.0)	(15.5–18.9)	(11.0–11.9)	(7.1–8.9)	(7.0–9.3)	(3.6–4.3)	(3.8–6.7)	(3.0–3.4)
P. p. rhoadsi (Hillsborough & Seminole cos., Fla.)	6 ♂♂	121	44	17	22.1	16.4	11.7	8.3	8.6	3.9	5.5	3.2
	6 ♀♀	(115–132)	(39–19)	(15–19)	(21.5–23.4)	(15.9–17.6)	(11.2–12.2)	(7.9–9.0)	(8.2–9.1)	(3.5–4.5)	(5.1–5.9)	(3.0–3.6)

size, and from *rhoadsi* in darker (less reddish) coloration. Comparison of cranial measurements of *lucubrans* and the other subspecies of oldfield mice may be made in Table 1.

The variation in the series of twenty-three adult skins at hand is noteworthy. The skins may be divided into four groups. These groups are correlated neither with geography nor with season, and seem to be rather dependent upon age of the individual and degree of wear. Group 1 is composed of seven individuals that are grayer than the type in color; these are skins taken in October and November and are presumed to represent the worn pelage. Group 2 is represented by seven specimens that are brown rather than gray, but are not quite so bright as the type; this series grades imperceptibly into Group 3, of which there are seven specimens (including the type). The third group shows more reddish coloration; both Groups 2 and 3 contain specimens in fresh pelage and are here considered to be typical of *lucubrans*. Group 4 is composed of two individuals, taken in November; both are extremely pale dorsally. The sides are Avellaneous, but the typical dorsal stripe is very inconspicuous (Wood Brown). The crown and face generally are likewise paler than the remaining specimens. These two individuals have the darker brown pigment much reduced on the dorsum, and black pigment is absent; apparently they represent a very local population of *P. p. lucubrans* at Talatha, Aiken County, South Carolina. The series of adults in fresh pelage (Groups 2 and 3) varies in coloration from specimens which resemble the type at one extreme to individuals at the other extreme in which the sides are Wood Brown and the dorsal stripe is close to Buffy Brown. In this entire series the tail is always distinctly bicolor.

Remarks.—The name *lucubrans* is derived from the Latin, meaning "working at night", an allusion to the nocturnal activities of these small mice.

Coleman states (*in litt.*) that *P. p. lucubrans* "appears to be restricted to sandy waste land without particular regard to the luxuriance of the weedy cover. The preferred habitat seems to be sandy fields adjoining cultivated land, especially land planted in cantaloupes, cucumbers or watermelons. I have never taken them in the immediate vicinity of the coast, nor on any of the sandy barrier islands along the coast."

Specimens examined.—(Specimens referable to races other than *P. p. lucubrans* have been listed in the 'Specimens examined' section of the description of the next race.) All from South Carolina, as follows: *Aiken Co.*, Atomic Energy Commission Savannah River Plant, 7; 4 mi. N Aiken, Shaw's Creek, on U.S. 1, 1; Talatha, 2. *Calhoun Co.*, St. Matthews, 1. *Orangeburg Co.*, 5 mi. W Orangeburg on S.C. highway 400, 1. *Bamberg Co.*, Little Salkehatchie River, 4 mi. W Denmark on S.C. highway 70, 5. *Barnwell Co.*, Atomic Energy Commission Savannah River Plant, 3; Ellenton, 1; 4 mi. S Barnwell on S. C. highway 64, 2; 5 mi. W Barnwell on S.C. highway 70, 3. *Allendale Co.*, 4.5 mi. E Savannah River on U.S. highway 301, 1. *Jasper Co.*, 7 mi. SE Ridgeland on S.C. highway 128, 1.

Peromyscus polionotus colemani, subsp. nov.

Holotype.—Adult female, skin and skull, no. 2076, collection of Robert H. Coleman; from ¾ miles east of Campton, Spartanburg County, South Carolina (Campton is about 2½ miles southeast of Inman, South Carolina); taken by Robert H. Coleman, November 27, 1947.

Distribution.—Generally, north of the Fall Line in South Carolina, Georgia, and Alabama, as far west as Centerville, Alabama (Fig. 1).

Diagnosis.—The darkest of the described races of *P. polionotus*. Skull typical of the species but differing in details as noted below.

Description of type.—External measurements: total length, 132; tail, 54; hind foot, 18; ear from notch, 14. Cranial measurements: greatest length, 22.9; basilar length, 16.9; zygomatic breadth, 12.3; interorbital constriction, 4.8; length of nasals, 9.4; palatilar length, 4.3; diastema, 5.8; alveolar length of upper molar row, 3.3. Color: sides, Light Drab, grading to a rather poorly defined dorsal band of Fuscous. Sides and dorsum overlaid with dark brown- to black-tipped guard hairs, giving a quite dark appearance. Cheeks, Vinaceous-Buff. Nose and crown dark, overlaid with dark (Fuscous) hairs. Ears, Fuscous-Black,

finely edged with whitish. Venter, white, hairs gray basally. Fore and hind feet, white; ankles, Fuscous. Tail sharply bicolor, Fuscous dorsally, white ventrally. Dorsal and ventral coloration of body sharply distinct.

Characters and comparisons.—Specimens here referred to *P. p. colemani* have previously been referred to the nominate race, *polionotus*. However, specimens of oldfield mice from approximately north and northeast of the Fall Line in the Piedmont are distinctly darker than Coastal Plain material. This was first noted by Coleman in regards to *polionotus* in South Carolina; however, comparison of Piedmont and Coastal Plain material from both Georgia and Alabama indicates that the color differences, first observed in South Carolinian specimens, are noticeable also in series from these latter areas. Other than distinguishing *colemani* from *polionotus* of the Coastal Plain in Alabama and Goergia, this darker coloration distinguishes the Piedmont subspecies from the Coastal Plain *lucubrans* in South Carolina and all the other named races of *P. polionotus*. *P. p. leucocephalus* from Santa Rosa Island, Escambia County, Florida, and *P. p. decoloratus* from the Florida east coast stand at the opposite extremes of the variation in color of the pelage in the species *polionotus*.

A comparison of specimens referred to *colemani* from South Carolina and Alabama shows that these two "terminal" populations possess certain cranial differences. Both populations average about equally in regards to total length, length of tail, and hind foot. Cranially, *colemani* from South Carolina average slightly smaller in greatest length, basilar length, length of nasals, palatilar length, and diastema. They average larger in zygomatic breadth. These differences are not correlated with any difference in pelage color, and specimens from Alabama and South Carolina are indistinguishable. Both series are small and there is a possibility that additional material will indicate that the western specimens, here assigned to *colemani*, will warrant separation from that form. Since such differences do exist, the following comparisons are based upon *colemani* from South Carolina and Georgia.

Comparison of *P. p. colemani* with *lucubrans* shows that there are no striking external (other than color) or cranial differences between these two forms; however, *colemani* averages somewhat wider as to zygomatic breadth and has on the average a shorter palate and a longer diastema. Comparison of cranial measurements of *colemani* with the remaining races of oldfield mice can be made in Table 1.

The coloration of a series of ten adult *P. p. colemani* from South Carolina is variable; the color of the pelage of the sides varies from Drab at one extreme to Avellaneous at the other. The dorsal band is moderately well defined but may be obscure in some individuals. The tail is always distinctly bicolor. A series of nine individuals from Georgia varies in color from Drab to Cinnamon-Buff. The tail is again sharply bicolor, and the dorsal band moderately well defined. A series of thirteen adults from Alabama varies between Drab and Wood Brown in lateral coloration; the tail is bicolor. The venter in all individuals is white with the hairs gray at their bases.

Remarks.—Although intergradation undoubtedly occurs between *colemani* and *polionotus* along the Fall Line in Georgia and Alabama, and between *colemani* and *lucubrans* along the Fall Line in South Carolina, no specimens demonstrating this fact are at hand. Three specimens from Donovan, Johnson County, Georgia, a locality not too distant from the Fall Line, are referable to *polionotus*. A large series from Butler, Taylor County, Georgia, seems referable to the Coastal Plain form. Likewise, a specimen from 16 miles SE Augusta, Richmond County, is typical of *polionotus*. In South Carolina, a single specimen from 4 miles N Aiken, Aiken County, is referable to *lucubrans*; this locality is the only locality in South Carolina from which any material is presently available from which intergrades between *colemani* and *lucubrans* might be expected. All specimens examined from Alabama are referable to either *colemani* or *polionotus*; no material assignable to *P. p. albifrons* from the southern portion of the state has been studied. A specimen from 7 miles N Macon, Jones County, Georgia, a locality presumed to be within the range of *colemani*, has been assigned to *polionotus*; this individual resembles *polionotus* in color of pelage, although the locality indicated is on the Piedmont.

A specimen recorded by Dice (1934:346) from Tallulah Falls, Rabun County, Georgia, is presumed, on geographic grounds, to be assignable to *P. p. colemani*.

Coleman, who has collected *P. p. colemani* in South Carolina, states (*in litt.*) that this race "occurs chiefly in old fields in which few or no small trees or shrubs have become established, on weedy terraces, and in marginal land on ditch banks and the edges of cultivated fields. At times these mice are relatively common in newly mown grain fields. Traps set in the same fields before the grain was cut caught no specimens. Nowhere have I found them to be really abundant. They appear to be indifferent to soil type, for I have taken them on rocky hillsides of red clay, in upland loamy soil, and in the black soil of river bottom lands. Their range extends well into the foothills of the mountains to an altitude of at least 1500 feet." Howell (1921:45) states of specimens taken at Autaugaville, Alabama, and now referred to *colemani*, that this species "is apparently more abundant than in other sections visited. Here they live chiefly in cultivated land, particularly in cornfields, but range also into open timbered tracts." At Sand Mountain, Alabama, Howell (*loc. cit.*) indicates that "they live in cultivated fields of cotton and corn, preferring sandy soils, but ranging into some that are rather clayey and also to some extent into weedy hedgerows and the edges of open timber." Sumner (1926:159) collected material at Autaugaville, Alabama, and mentions that "practically all of the *polionotus* were taken within or on the borders of fields devoted to corn, cotton, and peanuts." It is obvious that *P. p. colemani* occupies within its range a wide variety of habitats; its predilection for old fields is apparent.

Of the five races of *Peromyscus polionotus* regarded as oldfield mice, there is a variation in the ratio of the tail length to total length. *P. p. lucubrans* has the relatively longest tail (38.2%). This race occupies the extreme northeast section of the range of the species. Both *P. p. polionotus* and *P. p. colemani*, the two races which occur below and above the Fall Line in Georgia and Alabama, show a variation in the tail-total length ratio, with populations in the eastern portion of the ranges of these two forms having the longer tails (37.4% and 37.1% respectively), and those in the western portion of the range of these two forms having the shorter tails (35.1% and 36.6% respectively). Both *subgriseus* and *rhoadsi* have tails of the same relative length (36.7% and 36.9% respectively). *P. p. albifrons* has a relatively longer tail (37.6%) as compared with *subgriseus* to the south and *polionotus* to the north. In general it may be stated that the eastern and northern populations and subspecies have relatively longer tails than the western and southern populations and subspecies; *albifrons* on the Gulf Coast is an exception to this statement. No comparison has been made between the old field and beach inhabiting subspecies of *polionotus*.

Specimens examined.—*P. p. colemani:* **South Carolina,** *Greenville Co.*, River Falls, 1; 2 mi. N Cleveland, 1. *Spartanburg Co.*, Inman, 1; 1 mi. E Inman, 2; 1.5 mi. N Inman, 3; ¾ mi. E Campton, 2. *Abbeville Co.*, Abbeville, 1. *McCormick Co.*, 3 mi. N McCormick, 1. **Georgia,** *Cherokee Co.*, 5 mi. N Canton, 2. *Clarke Co.*, Athens, 3; Whitehall, 6. **Alabama,** *Jackson Co.*, Sand Mountain, near Carpenter, 3. *Bibb Co.*, Centerville, 1. *Autauga Co.*, Autaugaville, 9.

P. p. polionotus: **Georgia,** *Richmond Co.*, 16 mi. SE Augusta, 1. *Jones Co.*, 7 mi. N Macon, highway 129, 1. *Screven Co.*, 1 mi. W Savannah River, highway 73, 12; Hursman's Lake (Savannah River), near Bascom, 19. *Johnson Co.*, Donovan, 3. *Taylor Co.*, Butler, 16. *Emanuel Co.*, Adrian, 1. *Turner Co.*, 9 mi. E Sycamore, 1. *McIntosh Co.*, 6 mi. SW Townsend, 5. *Tift Co.*, 1 mi. E Tifton, 1. **Alabama,** *Henry Co*, Abbeville, 10. **Florida,** *Escambia Co.*, Century, 3. *Washington Co.*, 3 mi. S Chipley, 2. *Jackson Co.*, 3 mi. NE Graceville, 2; Marianna, 17. Intergrades between *P. p. polionotus* and *P. p. albifrons:* **Georgia,** *Baker Co.*, west bank of Ichawaynochaway Creek, ½ mi. below U.S. 91, 3. *Miller Co.*, 7.5 mi. E Colquitt, 1. *Thomas Co.*, Thomasville, 3.

P. p. albifrons: **Georgia,** *Grady Co.*, Beachton, 3. **Florida,** *Gadsden Co.*, Quincy, 12. *Walton Co.*, Whitfield, 6.

P. p. subgriseus: **Florida,** *Alachua Co.*, Gainesville, 9; 2 mi. S Gainesville, 6; 2.5 mi. S Gainesville, 4; 3 mi. S Gainesville, 1; ½ mi. N, ½ mi. E Payne's Prairie, 1; ½ mi. N Payne's

Prairie, 2; ½ mi. SW Lake Alice, 1; Newberry, 18. *Dixie Co.*, Eugene, 2. *Marion Co.*, McIntosh, 5; 20 mi. NE Ocala at Lake Bryant, 1; Ocala, 4. County indeterminable, Ocala National Forest, 5. Intergrades between *P. p. subgriseus* and *P. p. rhoadsi*; **Florida,** *Lake Co.*, Tavares, 8; Eustis, 11; Emeralda, 14.

P. p. rhoadsi: **Florida,** *Seminole Co.*, Oviedo, 6; 2 mi. E Oviedo, 6. *Orange Co.*, Union Park, 4. *Pasco Co.*, Dade City, 1. *Hillsborough Co.*, head of Anclote River; 1; Dug Creek, 6; *Pinellas Co.*, Tarpon Springs, 1.

P. p. phasma: **Florida,** *St. John's Co.*, Anastasia Island, 12.

P. p. decoloratus: **Florida,** *Volusia Co.*, Ponce Park, 9.

P. p. niveiventris: **Florida:** *Brevard Co.*, Chester Shoals, 1; Oak Lodge, east peninsula opposite Micco, 9; 5.4 mi. S Indialantic, 4; 7.2 mi. S Indialantic, 1.

P. p. leucocephalus: **Florida,** *Escambia Co.*, Santa Rosa Island, 14.

P. p. peninsularis: **Florida,** *Gulf Co.*, Cape San Blas, 18.8 mi. W Apalachicola, 10.

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AN ANALYSIS OF SUBSPECIFIC VARIATIONS IN *DIPODOMYS NITRATOIDES*

By Richard A. Boolootian

The present paper deals with a critical analysis of the subspecific variations in *Dipodomys nitratoides*. Grinnell (1922) discussed this species, the smallest of the San Joaquin Valley kangaroo rats, as three subspecies. These are *D. n. nitratoides*, *D. n. exilis*, and *D. n. brevinasus*. The species is distributed in Fresno, Kern, Kings, San Benito, and Tulare counties (Fig. 1).

The floor of the San Joaquin Valley is undergoing major agricultural expansion, and in all probabliity many of the burrowing animals of the valley may soon be eliminated from their present habitat and range. This is the case with the kangaroo rats.

This study is necessary because it represents perhaps the last opportunity to examine Grinnell's findings. Specimens were trapped and their localities mapped; then statistical methods were applied to various measurements such as tail length, hind foot length, red pelage color, bullae width, and skull length, in order to understand the systematic relationship among these subspecies.

The photoelectric reflectionmeter was made possible by a grant, No. 1064, from the Penrose Fund through the American Philosophical Society to Dr. Lloyd G. Ingles.

I wish to thank Drs. Albert C. Hawbecker, Lloyd G. Ingles, Charles H. Quibell, Francis Smith, and Miss Alice Bell, all of Fresno State College. In addition I thank my wife to whom I am especially indebted for preparing the final copy, and verifying all mathematical calculations.

Historical.—Mearns (1890) first described and named *Dipodomys merriami*. It was collected from New River in Maricopa County, north of Phoenix, Arizona, (type locality). In 1894, Merriam described and named a new subspecies of the *merriami* group as *D. merriami nitratus*. This was collected at Keeler, on the east side of Owens Lake, California. Merriam's description of *D. m. nitratus* referred to Mearn's original description of *D. merriami*, and gave the general characteristics as smaller than Mearn's *D. merriami*, with relatively larger hind feet, wholly different coloration, and with dusky markings obsolete. This subspecies of the *merriami* group is found nearest geographically to the subspecies under consideration here.

Merriam (1894) then described two new subspecies from the San Joaquin Valley, California. Clark P. Streator collected the type specimen of one from Tipton, San Joaquin Valley, California, June 25, 1893. Merriam named it *D. merriami nitratoides*, and gave the general characteristics as similar to *D. m. nitratus* in size and color, but with a strongly marked facial crescent meeting over the bridge of the nose, and also with smaller ears. The second new subspecies named by Merriam was collected by Vernon Bailey in 1891, September 23, Fresno, San Joaquin Valley, California, (type locality). The subspecific name given by Merriam was *D. m. exilis*; and the general characteristics of this subspecies were said to be similar to Mearn's *D. merriami*, but smaller and

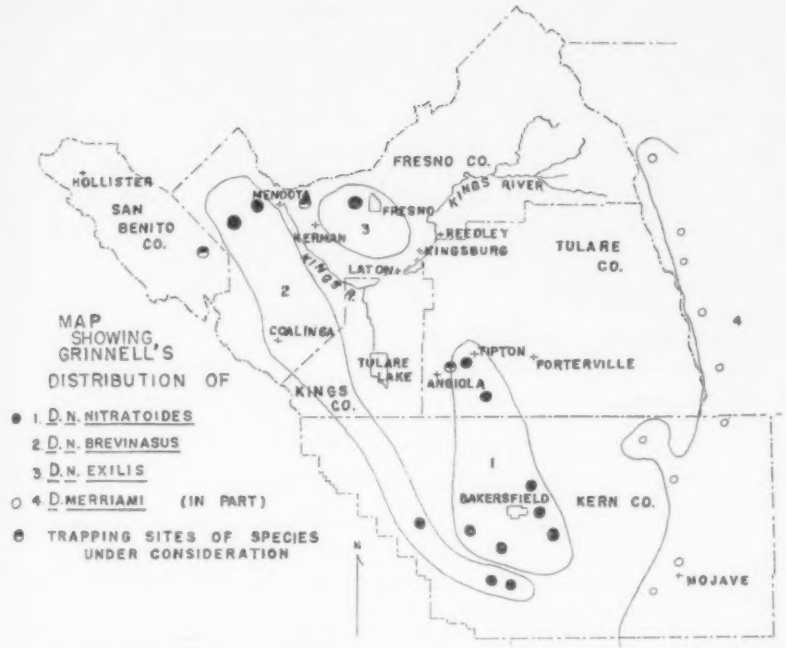

FIG. 1.—Showing Grinnell's distribution of *D. nitratoides* and *D. merriami* (in part). Trapping sites of species under consideration is also shown.

darker, with the upper surface of the nose and the posterior aspect of the ankles, black.

Grinnell (1920) described and named the third subspecies of the *D. merriami* group as *D. merriami brevinasus*. It was collected by Richard Hunt at Hayes Station, near B. M. 503, 19 miles southwest of Mendota, Fresno County, California, June 30, 1918, (type locality). Grinnell (1920) described this subspecies as being a broad-faced, four-toed, small-sized kangaroo rat belonging to the *merriami* group. Coloration was similar to that in *nitratoides* but paler in tone. With respect to the skull it was nearest like *nitratoides*, in that the rostrum at the base and the premaxillary tongues were conspicuously narrower than in *merriami* but the mastoid bullae were larger and the mastoid width was decidedly greater, with the interparietal and supraoccipital narrower. The general size was very slightly larger than in *nitratoides*, but much larger than in *exilis*.

Grinnell (1914, I have not seen this article) placed *D. m. nitratus* into synonymy under *D. m. merriami*. According to Grinnell (1922), all members of the *D. merriami* group definitely and invariably lack the first toe and claw on the hind foot.

In Grinnell's study of kangaroo rats of California (1922) comparisons were

made between *D. m. merriami* and *D. m. nitratoides*. At a first glance *nitratoides* appears to differ but scarcely at all from *merriami*, but with close examination Grinnell found many excellent distinguishing characteristics. One unfailing characteristic is external; the dark dorsal and ventral tail stripes in *nitratoides* are broader than the white lateral tail stripes. Conversely, in *merriami*, the white lateral tail stripes are always broader than the dark dorsal one, and the dark ventral one is even narrower or almost lacking. Cranially, *nitratoides* resembles *merriami* in many respects; however, there is a very positive difference in the narrowness of the rostrum. In *nitratoides* the sides of the rostrum are more nearly parallel to one another, and the angle formed by each side with the anterior margin of the adjacent maxillary arch is better defined and less obtuse. The nasals and the rostrum itself are distinctly shorter.

Grinnell found these external and cranial differences constant in the material he studied; hence the specific status of *nitratoides* was described and established by him (Grinnell, 1922).

Grinnell, in this same study, compared the three subspecies of *D. nitratoides*. In the comparisons, he discussed the status of *D. n. exilis* as similar to *D. n. nitratoides* in general characteristics, but decidedly smaller in size. He asserts that a glance at the ear, hind foot, and skull is usually sufficient to make identity of any specimen certain. *Exilis* is the darkest member of its group, the bullae are much smaller than in *nitratoides*, and the rostrum much shorter.

Only four specimens of this subspecies were available at the time of Grinnell's study. Many efforts were made by him to get fresh specimens, but he failed in his attempts. At this time it was thought that the subspecies was extinct because of intense cultivation of the area.

After a series of trappings Culbertson (1934) showed that *exilis* was not extinct and that its range was greater than had been supposed. The specimens collected by Culbertson were from areas east, west, and south of Kerman, Fresno County, California.

METHODS

In the course of this work 300 *Dipodomys nitratoides* were trapped in Fresno, Tulare, and San Benito counties. From these specimens, 55 adults of each of the three subspecies were selected. Adults were determined by size, molt, color, measurements, and cranial and dental differentiations. The animals were prepared as conventional study skins.

An attempt was made visually on the basis of color and size to separate the species into the three categories of Grinnell. This proved unsuccessful. A similar attempt was made to separate them into two groups. This was successfully done, but the reliability of such a method of segregation could be questioned. The *D. n. exilis* appeared to be about the same size as *D. n. nitratoides*, and *D. n. brevinasus* appeared to be, on the average, much larger than the other two groups.

Discarding the above methods, the next attempt involved a statistical interpretation of the variables usually considered in such a study. The tail vertebrae were measured from a point on the upper side at the base where the tail can be bent at right angles to the body. The hind foot was measured from the posteriormost point on the heel to the tip of the longest claw. Breadth of skull across bullae was measured across the widest possible transverse dimension of the skull taken at right angles to its axis. The skull length was measured by taking the length parallel to the axis of the skull with one jaw of the calipers touching the

TABLE 1.—*Summary of measurements. The first figure given is the mean, the second is the standard deviation* $\left(SD = \sqrt{\frac{\Sigma d^2}{N}}\right)$, *the third the standard error* $\left(SE = \pm\frac{SD}{\sqrt{N}}\right)$, *the fourth the number of specimens measured*

	Tail Length	Hind Foot	Per Cent Red Pigment	Bulla Width	Condylobasal Length
D. n. nitratoides	137.66	34.0	15.8	21.64	29.88
	6.748	.953	1.369	.696	.927
	.927	.129	.185	.098	.131
	53	55	55	50	50
D. n. exilis	137.43	33.4	16.2	21.65	29.74
	6.391	1.037	1.867	.522	.720
	.878	.139	.264	.074	.102
	53	55	55	50	50
D. n. brevinasus	148.79	36.0	17.7	22.60	3.42
	8.974	.944	1.692	.522	.759
	1.233	.127	.228	.074	.107
	53	55	55	50	50

anterior base of incisors and the other jaw touching the posteriormost points on the two backward bulging bullae. Red pigmental measurements were taken with a photovolt photoelectric reflectionmeter. Qualitative measurements of the red color of the pelage were easily obtained as per cent of the reading obtained from light reflected from magnesium oxide. All pigmental readings were made on a dorsal area just anterior to the pelvic girdle.

All linear measurements are in millimeters. A vernier calipers was employed in the skull measurements; measurements are correct with a margin of error of less than one-tenth of a millimeter. Table 1 summarizes the means, standard deviation, and standard errors of the five independent measurements. The reduction in the number of specimens as shown in Table 1 resulted from specimens damaged by trapping.

Grinnell's descriptions and comparisons of the three subspecies of *Dipodomys nitratoides* make reference to bullae size, condylobasal length, hind foot, and pelage color as the distinguishing characteristics.

In this study the method of Dice and Leraas (1936) has been used to portray the variations in the five measured characteristics (Fig. 2). The mean is shown as the perpendicular line at the center of each figure, the extreme limits of the sample are shown as the ends of the fine lines, the standard deviation as the heavy line, and the boxes are twice the standard error on each side of the mean. In general, if the vertical positions of the boxes do not overlap, the populations in question will show a t value in excess of the 5 per cent limit; that is, there will be a significant difference between the populations.

TRAPPING SITES

Trapping of the animals was conducted at three separate sites, actually at one particular site for each subspecies. The entire work was confined to the three areas covering Fresno, San Benito, and Tulare counties. The animals were trapped between September 19, 1952, and January 15, 1953. To show how much variation is present in the habitat of each subspecies a brief ecological description of each site follows.

Site one.—This area is located exactly 21.5 miles west of Fresno or 6.5 miles west of the junction of Highways 180 and 145, on Highway 180. At this site there are two types of terrain. Over most of the area there are elevations and depressions up to six feet. During the rainy season the depressions become temporary ponds. Lack of drainage results in a heavily

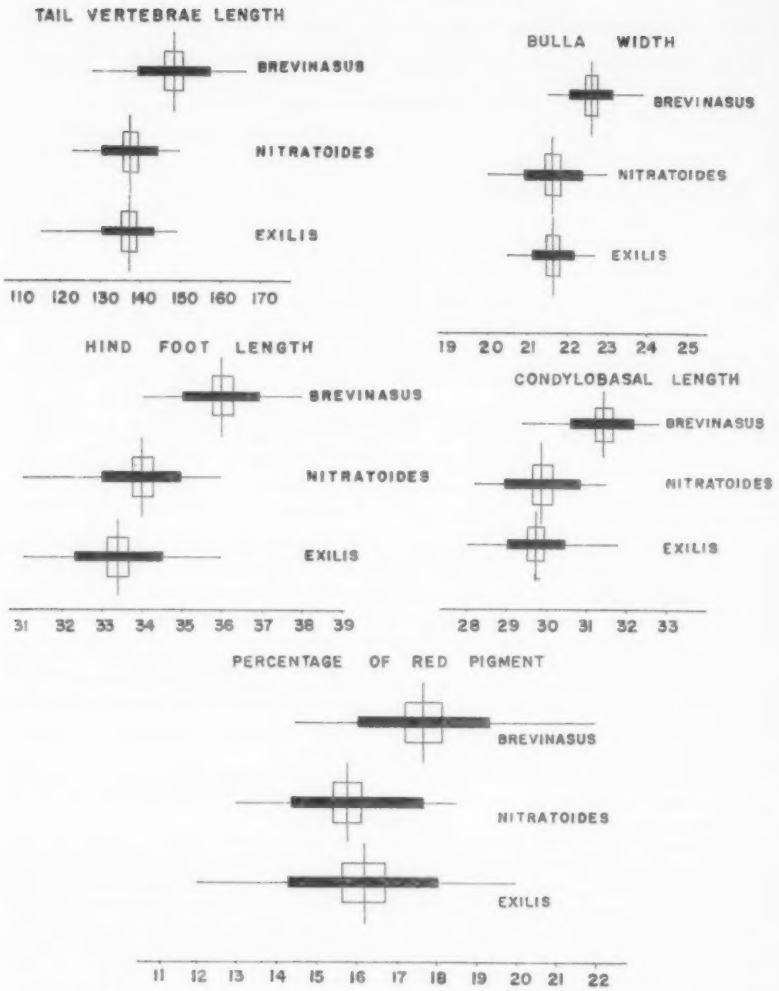

FIG. 2.—Graph of measurements of the length of the tail vertebrae, the length of the hind foot, the condylobasal length, the bulla width, and the percentage of red pigment. See text for explanation.

alkaline soil, especially in the depressions. Here also the surface dries hard during summer months.

Burrow systems were never observed in the low depressions. The soil on the elevated regions is alkaline also, but it is soft and light, often the surface is a powdery dust, making an excellent situation for burrow systems. The only vegetation is on the raised spots and consists chiefly of grasses and alkali blite (*Suaeda maguini*).

The other type of terrain consists of flat irregular strips running through the elevated regions generally in a north-south direction. The elevation of the strips is about even with the tops of the elevated irregular terrain. Digging in this type of soil is easily done. Most of the burrow systems were observed on this area. Vegetation is more abundant with scattered clumps of salt brush (*Atriplex* sp.). In winter the rains bring a heavy matted growth of winter annuals; pepper grass (*Lepidium nitidum*), shepherd's purse (*Capsella bursa-pastoris*), and filaree (*Erodium* sp.) are very abundant (Culbertson, 1946).

Other vertebrate animals that were trapped or seen in the same area are *D. h. heermanni*, *Peromyscus maniculatus*, *Perognathus inornatus*, and *Lepus californicus*.

The above area is now being leveled for cultivation. Possibly the entire area west of Kerman will be under cultivation within the next ten years. This will definitely eliminate the habitat of Grinnell's subspecies *exilis* and cause the extinction of his Fresno kangaroo rat.

Site two.—Approximately 11 miles east of Llanada, San Benito County, California, (Panoche Quadrangle) U.S.G.S., is an area ranging in elevation from 1000 feet to 1800 feet where in a small area a number of varied rodent habitats may be found.

The trapping site is located in an *Ephedra* community. The habitat on which the *D. n. brevinasus* is found is on the tops of rolling hills where slopes are gentle and flats are broad, rocky outcrops with *Ephedra* being generally absent. These slopes and flats extend down to bases of steep hills. Any sudden change in slope will eliminate this habitat immediately. The three most prominent annuals found on these slopes are *Bromus rubens*, *Erodium circutarium*, *Lepidium nitidum*, and the perennial, *Poa scabrella*. Some scattered *Gutierrezia californica* are found on these hill tops. The soil is firm but easily spaded both in winter and summer (Hawbecker, 1951). The soil is less alkaline than in the trapping sites in the San Joaquin Valley.

Trapping or observation indicate that the other mammals on this site are as follows: *Peromyscus maniculatus*, *Lepus californicus*, *Dipodomys heermanni*, *Citellus nelsoni*, *Perognathus inornatus*, *Dipodomys ingens* and *Vulpes macrotis*.

Site three.—This site is located two miles northeast of Angiola, Tulare County, California. Most of the immediate territory is under cultivation, and probably within the next decade the entire region will be cultivated. The territory where trapping was first conducted is relatively flat with only a few minor uplifts or mounds. This feature evidently influences the choice of habitat by *D. n. nitratoides*; the animal is not abundant on this type of terrain, since, during the rainy season, the entire flat is muddy and unsuitable for kangaroo rat burrows.

The first two trips to this region resulted in only eight specimens. On the third trip many burrow systems were discovered along the well-drained, low banks bordering the roads. Traps were set at these burrow systems, and many *D. n. nitratoides* were trapped. Evidently the animals are better adapted to this habitat because the banks are elevated three or four feet. This enables the animals to survive unfavorable environmental conditions. The typical plant life in this territory is alkali blite (*Suaeda moquini*), common spikeweed (*Centromadia pungens*), farmer's foxtail (*Hordeum murinum*), and wild barley (*Hordeum depressum*). Trapping records indicate the presence of *D. heermanni*, *Peromyscus maniculatus*, *Perognathus inornatus*, and *Reithrodontomys megalotis*.

DISCUSSION

As the taxonomy of subspecies must of necessity be based on morphological characters (Dice, 1940), a discussion of the pelage and the dimensions of the body and its parts will form the basis of this work.

The Dice-Leraas (1936) method, as previously mentioned, was used to compare the variables (Fig. 2). On the basis of this, the hind foot is the only measured characteristic that shows a significant difference in excess of the 5 per cent limit among all three subspecies.

Grinnell (1922) stated that the barrier between *exilis* and *nitratoides* is the Kings River, which enters the San Joaquin Valley from the eastern side of the valley and runs in a southwesterly direction; then, at Lemoore the river branches, and one section enters the Tulare Lake basin, and the other extends northwest towards Mendota. Therefore, this river also serves as a barrier between the two assumed valley races and *brevinasus*. The Kings River serving as more than a weak barrier is questionable, because records of this river's history, kept by Mr. Charles L. Kaupke, Chief Engineer and Watermaster of Kings River Water Association, Fresno, California, dating back to 1871, indicate the river dried up as far east as Reedley, California, in 1924 and 1931. Also Mr. Kaupke stated that at least five months out of the year the river is dry west from a point four miles southwest of Laton. At this location there is a weir that prevents water from going any farther. Before man's control of the Kings River, it was learned from the same source, the river did not hold a true course for any period of time. Many times the river has changed from its old route to a new one. Since all of the above conditions have existed from time to time, it seems reasonable that the Kings River should not be considered a geographical barrier. The same condition holds true in relation to *brevinasus* as with the two valley races. *Brevinasus* apparently prefers a soil type of low alkali content, and is found at a higher altitude where climatic conditions may be slightly different from valley conditions.

The interpretation of these data is that *D. n. exilis* should be placed in synonymy with *D. n. nitratoides*. I, therefore, place *D. n. exilis* in synonymy under *D. n. nitratoides* in accordance with Article 28, Recommendation c, Law of Priority, International Code of Zoological Nomenclature (McMasters and Schenk, 1936).

SUMMARY

Fifty-five specimens of *D. nitratoides* were selected from larger collections at each of three sites. The Dice-Leraas system was employed for statistical interpretation of measured variables. There were no significant differences between *D. n. exilis* and *D. n. nitratoides*, with the exception of the hind foot; significant differences existed between *D. n. brevinasus* and these two races. Hence, *D. n. exilis* is reduced to synonymy under *D. n. nitratoides*. A problem that should be considered in the future is the range of the two subspecies.

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GENERAL NOTES

NEW MAMMAL RECORDS FOR NEVADA

The records that follow provide extensions of known geographic range for several native mammals of Nevada and include the first record for the state for each of two species. Hall's contribution (MAMMALS OF NEVADA, Univ. California Press, Berkeley, 1946) has been consulted as a basis for the evaluation of all records.

Ursus americanus (Miller).—Black bear. On a day in October, 1950, Mr. V. Nickovich of Reno found fresh black bear tracks and droppings in the snow near Barney Riley along Bryant Creek, Douglas County. Previously he had hunted considerably in this region, but had never seen evidence of bear. Later in the same day the caretaker of a mine in the area told Nickovich that seven or eight black bears had been brought in from Yosemite National Park, and that they were becoming a nuisance about the garbage disposal at the mine. However, black bears native in the Canadian Life Zone of California a few miles distant may visit the Barney Riley area near the California state line, for an isolated stand of mature Jeffrey pine surrounded by pinyon occurs there, which supports a small fauna of the Transition Life Zone. In July, 1953, I recorded two Douglas squirrels (*Tamiasciurus douglasii*) and several species of birds, known formerly in Nevada only from the vicinity of Lake Tahoe, as resident in the Bryant Creek area. This limited representation of montane forest and attendant fauna barely brushes the Nevada state line. In the late spring of 1949, Mr. Bill Dunning, student at the University of Nevada, encountered an adult bear in the pinyon woodland approximately twelve miles southeast of Carson City (Ormsby County) in the Pine Nut Mountains of northern Douglas County. Perhaps this individual was a vagrant from the population near Lake Tahoe. Previous to these reports the black bear was known to occur in Nevada only in the Carson Range near Lake Tahoe in the Sierra Nevada Faunal Area. Recent sight records from this region that supplement those given by Hall include a quarter-grown cub which I saw on August 30, 1949, rambling up a rock slide at approximately 6000 feet elevation in Hunter Creek Canyon west of Reno, Washoe County. Early in September, 1949, W. Verne Woodbury of Reno saw a large bear, presumably adult, at the edge of a meadow one mile further up the same canyon at 6200 feet.

Bassariscus astutus (Miller).—Ring-tailed cat. Hall lists two record stations for this species and states that it "probably ranges over the southern third of the state." These two localities are Meadow Valley Wash, Lincoln County, and El Dorado Canyon, Clark County. La Rivers (Amer. Midl. Nat., 32: 422) gives an account of a sight record of this mammal at a Brewer Blackbird (*Euphagus cyanocephalus*) nest on Peavine Mountain, southern Washoe County. At a September, 1953, conversation La Rivers mentioned that he had seen and followed a ring-tailed cat also on the rocky slopes along the west side of

Walker Lake, Mineral County on July 23, 1949. Robert Bandoni, student presently at Iowa State College, reports to me that a ring-tailed cat was struck by a car along the west side of Walker Lake some time in 1950, and that he was able to see the specimen, which was submitted to a Mrs. William Lyle of Hawthorne to be mounted for display. There is a mounted individual on deposit at the University of Nevada. According to Dr. Ira La Rivers that specimen was obtained by Professor C. L. Brown, formerly of the University of Nevada, at an unknown date, from a person at Verdi, Nevada, who had it for a pet. Whether the animal came from the Verdi area is not known. These records extend the known range of this species in Nevada at least 175 miles further north than the range suspected by Hall, and approximately 325 miles distant from the nearest published record in Nevada.

Sciurus griseus Ord.—Gray squirrel. On November 28, 1952, my wife, Beverly, and I observed a single gray squirrel loping among the needle litter and *Ceanothus* brush in a open second-growth Jeffrey pine forest near the Clear Creek Highway at 6000 feet, three miles south and five miles west of Carson City, Ormsby County, in the Carson Range. This individual is referred to the species *S. griseus* on geographic grounds, for that species is known from adjacent regions of the Sierra Nevada in California. We watched the squirrel for almost a minute from a distance of about thirty feet as it worked about in a clearing along the highway. Its large, bushy, dark and white tail and pale gray body were closely observed, making the identification certain. This appears to be the first published record of its occurrence in Nevada.

Phenacomys intermedius celsus (Howell). Sierran Phenacomys.—Mr. John S. Spencer of Reno and I took a male of this species on May 17, 1953, one-half mile south of Grass Lake at a point two and one-half miles east and one mile south of Mt. Rose peak at an elevation of 7800 feet, in the Carson Range of Washoe County. The following measurements were taken from the specimen: total length, 135 mm.; tail, 30; hind foot, 19; and ear from notch, 14. To my knowledge this is the first known occurrence of this species in the state of Nevada. I thank Dr. E. Raymond Hall for identifying the specimen. The animal was caught in a homemade intermediate rat-mouse kill trap, baited with a peanut butter-raisin mixture, set at a burrow hollowed in a mat of needles and wood debris beneath a small lodgepole pine next to a snowbank. The locality is in the Sierran Subalpine Forest vegetational type with red fir and white fir in mixed, thin stands, and second-growth Jeffrey pine secondarily dominant. At least fifty per cent of the ground was snow-covered at the time of the capture, and the ground supported a good growth of *Ceanothus*. Low herbaceous species were uncommon, and the soil was sandy with large granitic boulders scattered about. In addition to the *Phenacomys* we captured at this locality nine *Peromyscus maniculatus* and three *Microtus longicaudus* in our line of thirty-four rat and mouse traps. Spencer captured a chipmunk by hand which we have tentatively identified as *Eutamias amoenus*. The wet ground at a nearby spring is inhabited by the mountain beaver (*Aplodontia rufa*). Spencer examined an *Aplodontia* captured there in a muskrat trap in May, 1948.

I wish to express my appreciation to all of the persons who have made their records available to me for this report. Dr. Hall examined the manuscript and made helpful suggestions.—Ned K. Johnson, *University of Nevada Museum of Biology, Reno, Nevada, September 30, 1953.*

NEVADA MAMMAL RECORDS

Since the publication of E. R. Hall's MAMMALS OF NEVADA in 1946, several new records have accumulated which seem worthy of publication. Two species may be added to the mammals known to occur in the state:

Sciurus griseus griseus. California gray squirrel.—This species has now been collected at Verdi, Washoe County, near the California state line, and seen several times along the base of the Carson Range between Reno and just south of Carson City. This squirrel occurs along the west slope of the Sierra Nevada at least as high as 7700 feet at times. It could cross the northern Sierra Nevada in regions much lower than this but perhaps has not become better established in Nevada because of the absence of oak trees.

Myocastor coypus. Nutria.—Introduced in Lahontan Valley, Churchill County, over ten years ago, and more recently in Truckee Meadows, Washoe County; this Central American rodent has now become established in the wild especially in the Lahontan Valley.

Several marked range extensions or new records of little-known species of mammals in Nevada can be listed:

Lasiurus borealis. Red bat.—A specimen from Reno, Washoe County, adds to the previous two records from Clark and Churchill counties.

Ursus americanus. Black bear.—Described by Hall as just from the Sierra Nevada Faunal Area in Nevada, there are records now of this bear's occurrence in the Pine Nut Range to the east (Douglas County) and also at least two records from Elko County, some 300 miles to the northeast. These latter records are presumably *U. a. cinnamomum*, as in Idaho.

Bassariscus astutus. Ring-tailed cat.—There are two records to be added from Peavine Mountain near Reno, rather than from just the southern third of the state. The new records appear to *B. a. raptor*, as in central California, instead of the desert subspecies *nevadensis*. The variety *raptor* occurs not more than 15 miles west of the Nevada state line and has probably crossed parts of the Sierra Nevada lower than some of its range in eastern California.

Procyon lotor. Raccoon.—Various records now extend the raccoon's range east to Lahontan Valley and down the Humboldt River to Lovelock, Pershing County.

Castor canadensis. Beaver.—Beavers are now introduced (chiefly *C. c. taylori* from Idaho) into many new parts of Nevada including the west-central rivers (Truckee, Carson, and Walker), where they did not occur originally but are now well established in some regions.

Cervus canadensis nelsoni. Elk or wapiti.—Elk were introduced into the Charleston Mountains, Clark County, over 20 years ago and are reported from several sources as still present in small numbers.

Lepus americanus tahoensis. Snowshoe rabbit.—Three new records of this species from the Lake Tahoe region can be added to Hall's single record.

With the exception of the bear, raccoon, and elk, these records are substantiated by specimens, all but the gray squirrel in the University of Nevada zoological collections. The bear and raccoon records are based on Fish and Wildlife and other trapping reports.—Frank Richardson, *Bernice P. Bishop Museum, Honolulu, Hawaii. Submitted October 9, 1953.*

MERRIAM'S LIFE ZONE CONCEPT AND THE DISTRIBUTION OF CERTAIN SMALL MAMMALS IN CENTRAL NEW YORK

Merriam's life zone concept of plant and animal distribution (1894) has, in the last two decades, been widely criticized by a number of botanists including Livingston and Shreve (1921) and Daubenmire (1938). More recently zoologists have figured prominently among the critics. These have included Ruthven (1920), Dice (1923), Kendeigh (1932), Shelford (1932, 1945), Peterson (1942), and Odum (1945). The present study is an attempt to demonstrate the validity or invalidity of Merriam's life zone concept in relation to the distribution of certain small mammals in central New York.

The study area, located in the Finger Lakes region of central New York, lies two miles east of the south end of Lake Cayuga. This area, as does most of New York state, lies within Merriam's Transition Life Zone (Merriam, *loc. cit.*). Peninsulas of the Upper Austral Life Zone extend into northwestern New York in the Buffalo-Rochester area and also northward along the Hudson River valley. Southern outposts of the Canadian Life Zone occur in the Adirondack and Catskill mountains. However, the nearest portion of the Canadian Life Zone proper lies roughly 200 miles to the north of the study area in southern Canada.

The vegetation of the study area is divisible into three major associations, each of which comprises about 15 acres. These include a) an elm-maple-ash-yellow birch swamp association, b) a beech-maple association, and c) an elm-oak-hickory-hornbeam association. A fourth division of the vegetation is the forest edge, a band of vegetation lying between the woodland proper and the immediately adjoining fields.

In an attempt to sample the composition of the small mammal population in the study area, five quadrats, each ten meters square were established. Two quadrats were placed in the swamp association and one each in the elm-oak-hickory, beech-maple, and forest edge habitats. During 1060 trap nights in September, 1949, and 1000 trap nights in June, 1950, a total of forty-nine small mammals were taken. Two of these mammals were smoky shrews (*Sorex fumeus fumeus*) and one was a red-backed mouse (*Clethrionomys gapperi gapperi*). These two species have definite Canadian Life Zone affinities. The Transition Life Zone is by definition a zone which includes faunal elements of both the Canadian and Austral life zones. Nevertheless, because these mammals with Canadian Life Zone affinities were taken exclusively from a single one of the swamp quadrats it was decided to analyze the swamp association from the standpoint of Merriam's life zone concept. Was this fifteen acre swamp association actually Transitional,—or could it validly be called a part of the Canadian Life Zone?

Merriam based his life zone boundaries on mean temperatures occurring during the six hottest weeks of the year. A thermograph was employed, therefore, to obtain these data for the swamp association. These temperatures were then compared with corresponding data recorded at the Caldwell Field Weather Station located only one mile west of the study area.

As previously stated, most of central New York lies within Merriam's Transition Life Zone. As determined by Merriam, this zone is limited on the south by a mean temperature of 71.6°F. during the six hottest weeks of the year. The northern limit of the Transition Zone, which is in effect also the southern limit of the Canadian Life Zone is determined by a mean temperature of 64.4°F. during the six hottest weeks of the year. Therefore, the average temperature difference for that period for the entire breadth of the Transition Life Zone is only 7.2°F. However, in the present study the average temperature difference for the six hottest weeks of 1949 between the swamp quadrat, which registered the lower temperature, and the Caldwell Field Weather Station was 9°F. *This is 1.8°F. in excess of the corresponding average temperature range over the entire breadth of the Transition Life Zone!*

How then shall the swamp association be classified in terms of Merriam's life zone concept? If Merriam's principles were applied to this relatively minute area, one would have no recourse but to regard the swamp association, from which the smoky shrews and red-backed mouse were taken, as an *isolated relic fragment of the Canadian Life Zone*. This fifteen acre swamp association therefore represents a tiny Canadian Life Zone "island" in the heart of the Transition Life Zone. The closest portion of the Canadian Life Zone proper is in southern Canada fully 200 miles to the north.

Merriam's life zones in eastern United States present roughly a pattern of broad bands passing in an easterly-westerly direction. His life zones are relatively simple in delineation and quite all-inclusive. However, a considerable portion of central New York is characterized by bogs or swamps very similar to that described in the present study area. Perhaps hundreds of such Canadian Life Zone "islands" occur throughout the Transition Zone in central New York. Merriam's Life Zone map (1894) indicates the occurrence of an exclusive Transition Zone fauna in central New York. In the light of the present study this is manifestly misrepresentative. An accurate life zone map of central New York would indicate a large number of tiny Canadian Life Zone "islands" occurring throughout the Transition Zone. Such a map would demonstrate a much more complex and irregular faunal distribution in central New York than presented by the over-simplified life zone map of Merriam.

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OLIVER S. OWEN, *Department of Biology, Bradley University, Peoria, Illinois.* *Received September 9, 1953.*

GRAY BULL MAMMALS FROM THE KNIGHT FORMATION IN MOFFAT COUNTY, COLORADO

During the field seasons of 1952 and 1953 parties from the University of California Museum of Paleontology, Berkeley, secured large collections of vertebrate remains from stratigraphically lower levels in the Knight formation than have hitherto proven fossiliferous. The new localities are in northeast Moffat County, Colorado, mostly in the region of Four Mile Creek, a tributary of the Little Snake River. Presence of such forms as *Nyctitherium*, *Apheliscus*, *Peratherium* or *Peradectes*, *Phenacolemur*, *Wasatchia*, two types of multituberculates, and primitives species of *Cynodontomys*, *Hyopsodus* and *Tetonius* suggests an age equivalent to that of the Gray Bull fauna of the Bighorn Basin, Wyoming. Such additional specific identifications as have been made to date strongly reinforce these conclusions. Mammalian genera now known only from the Lost Cabin fauna or its equivalents are not present at any of the newly discovered localities in Moffat County. More accurate age determination within Wasatchian time must await thorough study of the collections with particular consideration of paleoecology and of the fact that the geographic position of the localities is approximately midway between the classic collecting grounds of northwestern New Mexico and northern Wyoming. I wish at this time to designate the material from the Moffat County sites as representative of the *Four Mile Local Fauna*, this name being in reference to Four Mile Creek.—MALCOLM C. MCKENNA, *Department of Paleontology, University of California, Berkeley.* *Received October 13, 1953.*

THE SWIMMING OF THE OPOSSUM, *DIDELPHIS MARSUPIALIS VIRGINIANA*

During recent studies in connection with the preparation of a volume on the mammals of Pennsylvania I have had occasion to examine literature on the life history of the opossum, *Didelphis marsupialis virginiana*. Although several authors mention that the opossum swims, I have not found any description of the manner in which it accomplishes this. It seemed desirable, therefore, to examine this matter more carefully.

On February 2, 1953, I placed an opossum in a bathtub full of water at 5:10 PM. The opossum immediately dove under the surface of the water and swam the length of the tub (about 5 feet) before coming to the surface again. Its toes were spread wide apart. It swam with an action similar to that of a pacing horse; that is, the front and hind legs on the right side went forward together, while the front and hind legs on the left side came back on the power stroke. As its swimming strokes alternated from side to side, its tail also swung from side to side—which recalled to my mind the sculling of a boat. After the first short spurt under water it came to the surface and swam with its nose above water. Very shortly after being placed in the water it defecated, and during the course of the experiment this occurred twice again. After swimming for about five minutes the animal seemed a little tired and stopped to rest with its nose out of the water, its legs spread wide apart, and its tail outstretched. Its vibrissae were also spread wide. It appeared to float with ease.

After the first few minutes it changed its stroke from the pacing action to a walk-like motion, this time striking out with the left front foot, then the right hind foot, and so on. As the experiment progressed this stroke was used more than the original. It gave the impression of being a strong and experienced swimmer. Five strokes were sufficient to carry it the length of the five-foot bathtub. The hind legs reached far forward, up against the belly, and the forelegs reached almost to the neck. It was able to open and close its nostrils at will and sometimes rested with its nose under the water.

Although it was evidently a strong swimmer, it seemed to tire quickly, and frequently stopped to rest. I was not convinced that any of the sounds it made were definitely vocal, although it did produce a slight gurgling, grunting or snuffling noise. We could not certainly determine its source, but it may have been produced by bubbles being blown out through the nose. After the opossum had been in the water for 30 to 45 minutes it showed definite signs of fatigue. It rested with its head curled up against the side of its body, its tail bent forward with a small half inch curl in the tip.

At 6:03 we drained the tub. The opossum had been in the water for 53 minutes. During that time, however, it had had two or three rest periods, at which time the water was partially drained from the tub and the animal was allowed to rest on the bottom for five minutes or so before the tub was refilled. It was very tired, very cold, shivering and holding on to the drain. We lifted it out, dried it off and tried to warm it in front of an electric heater, but it continued to shiver. A thermometer was not available, so we were unable to take the temperature of the water, but it felt cold to the touch, although some warm water had been added to that from the cold water tap.

It seemed evident that this 53 minute immersion in the cold water was too much for the opossum, although we did not realize this until near the end of the experiment. I was much concerned about its well-being, so I fed it warm milk and bread, wrapped it in a warm blanket and placed it near the radiator. It gradually warmed up and by morning was quite normal again.

This experiment indicated that, although the opossum is a strong swimmer and has no fear of the water, it is not likely that it would voluntarily swim for any length of time in cold water. In fact, long immersion might kill it. It would seem, therefore, that a wide body of cold water could be an effective barrier to the distribution of the opossum.

On the evening of April 13, 1953, I captured another opossum. This was a young male, about half grown. It was kept in a cage until the evening of April 14. At 10:06 PM it was placed in a bathtub. Although the tub was filled with water nearly to the overflow outlet, the water was still not deep enough to prevent the opossum from resting occasionally on the bottom of the tub.

Immediately after being placed in the water it dove beneath the surface and swam approximately the length of the tub (five feet). Then it came to the surface and swam the length of the tub two or three times. It defecated in the water, then rested with its hind feet on the bottom of the tub. After a short rest it began to swim again, from end-to-end of the tub. This time its swimming seemed almost frantic. Its forked penis was distended and quite obvious.

When it first began to swim, it had the pace-like action described for opossum number one; later it swam with a walking motion—as the front leg came back for the power stroke, the hind leg on the same side was reaching forward. A little later it was observed to swim with a different stroke, both front legs coming back at the same time. The toes were at all times spread wide apart. At 10:10 it rested with its hind legs on the bottom of the tub, its nostrils out of the water, but its eyes beneath the surface, and open. This opossum made the same snuffling or grunting noise mentioned for opossum number one; in addition, it uttered a sort of whine, almost a purr.

After the first five minutes in the water it spent more time resting than swimming, half sitting on the bottom of the tub with its nose out of the water. It began to shiver, although the temperature of the water was 83°F. At 10:20 it was sitting on the bottom of the tub with its nose just out of the water; it was evidently tired and did not want to swim any longer. The water was let out and the experiment ended.

The following morning, April 15, at 7:45 AM, the same opossum was placed in a small farm pond, about one-tenth of an acre in extent. The water was too muddy to observe very clearly the strokes, but it seemed to swim dog-fashion. It swam approximately fifteen feet, until it was well past us, then climbed out on the bank, ran half a dozen paces or so, then stopped abruptly, turned, opened its mouth and hissed at us. We, in the meantime, stood perfectly still. It then ran on, climbed over a small raft which it could have just as easily avoided, and continued down over the hillside. It never took time to shake itself. As it ran down over the bank its forked penis, well distended, was distinctly visible. At 7:50 AM this experiment was ended.

From these experiments it is evident that the Virginia opossum swims with ease and considerable force. Its diving and swimming under the surface of the water would suggest that it is accustomed to water and has no fear of it. It may even use this device for eluding its predators. However, it is also evident that it cannot stand long immersion in cold water, and it seems likely that large bodies of cold water would be effective barriers to its distribution.—J. KENNETH DOUTT, *Carnegie Museum, Pittsburgh 13, Pennsylvania. Received February 7, 1954.*

IDENTITY OF THE PLEISTOCENE MOLE FROM GIBRALTAR

Bate (Jour. Roy. Anthro. Inst., 58:92–113, 1928) assigned to *Talpa europaea* some skeletal remains of moles associated with Neanderthal man and Mousterian culture from the Pleistocene of Devil's Tower, Gibraltar. Zeuner (THE PLEISTOCENE PERIOD. Printed for the Ray Society, London, p. 201, 1945) dates this fauna found at Devil's Tower as being from the very earliest phase of the Fourth (Würm) Glaciation.

These Gibraltar moles, particularly the limb bones, were considerably smaller than the corresponding bones of living *T. europaea*, but in spite of the fact that *T. caeca occidentalis*, a small subspecies of the southern European mole, occupies most of the Iberian peninsula (Cabrera, FAUNA IBERICA. MAMÍFEROS. Madrid, 1914), Miss Bate's published conclusion, although tentative, was that the Gibraltar mole belonged to *T. europaea*. Part of her confusion arose from the fact that she did not have for comparison any skeletal material of *T. caeca* (the material labeled *T. caeca* at that time in the British Museum (Natural History) was later identified as the larger *T. romana* from Italy). By 1937 (Stone Age of Mt. Carmel, 1: 170), Miss Bate had come to realize that the Gibraltar materials possibly belonged to *T. caeca*, and that the problem should be investigated further. She did not, however, publish again on the subject.

Re-examination of the original material in the British Museum (Natural History), and study of Miss Bate's correspondence on the subject, indicates that the Gibraltar mole should be assigned to *T. caeca*, and that she had come to this conclusion herself, after having a partial skeleton of this species prepared for the express purpose of making the comparison between the Pleistocene and Recent bones.

This note, then is merely to set on record a conclusion that Miss Bate had already reached, independently confirmed by myself; the Pleistocene mole from Gibraltar is *Talpa caeca* and not *T. europaea*. On geographical grounds it might be assigned to *T. c. occidentalis*, but I have not had available a skeleton of this Iberian form for comparison. Furthermore, considering the difference in time of some 50,000 or more years between the early Würm and the present, it might be wiser not to try to assign the Devil's Tower moles to a subspecies.—CHARLES A. REED, *College of Pharmacy, University of Illinois, Chicago. Received November 15, 1953.*

LONGTAIL SHREW, *SOREX DISPAR*, IN MAINE

On September 7, 1953, a male *Sorex dispar* was caught near the southwest edge of Lower South Branch Pond, Baxter State Park, T.5-R.9, Piscataquis Co., Maine. The animal measured: total length, 113 mm.; tail, 56; hind foot, 13; ear from notch, 9. Judging from the amount of toothwear, it was evidently a subadult. It was captured at a mossy spot between some rocks in a wooded rockslide at an elevation of approximately 1000 feet. Redback voles (*Clethrionomys*) and deer mice (*Peromyscus maniculatus*) were caught in similar situa-

tions in the same rockslide. This extends the range of the species from the White Mountains in New Hampshire (Preble, Jour. Mamm., 18:95, 1937) to central Maine, a distance of about 200 miles. The specimen is now in the mammal collection of the Museum of Zoology, University of Michigan, as skin and partial skeleton.

I wish to express my appreciation to Baxter State Park Supervisor Helon Taylor and the Baxter State Park Authority for granting permission to trap shrews and mice inside the park.—ANDREW STARRETT, *Museum of Zoology, University of Michigan, Ann Arbor.* *Received October 16, 1953.*

OCCURRENCE OF THE SEMINOLE BAT IN ARKANSAS

On August 9, 1953, a female Seminole bat, *Lasiurus seminolus* (Rhoads), was shot by Arnold J. Hoiberg near Newport landing on the Ouachita River, Ouachita County, in south-central Arkansas. This specimen (Univ. Arkansas Zool. Dept. collection, No. M53-30) constitutes the first known record of this species for the state. Lowery (Occ. Papers, No. 13, Mus. Zool., Louisiana State Univ., 1943) reports this species as rather rare in northern Louisiana. The present record is apparently the most northwesterly one for this species to date.

Lowery (ibid.) considers the possibility that the Seminole or mahogany bat may be a color phase of *L. b. borealis*. Other authors have considered it as a subspecies of *L. borealis*. Colin C. Sanborn (personal communication) has informed us that in a group of *Lasiurus* from Florida recently shot on the wing at the same time and place, five were dark *seminolus*, while one was a typical red *borealis*. The writers are inclined to accept the opinion of Barkalow (Jour. Mamm., 29: 415–416, 1948) that *L. borealis* and *L. seminolus* are distinct species in spite of their close associations.—JOHN A. SEALANDER, JR. AND ARNOLD J. HOIBERG, *Zoology Department, University of Arkansas, Fayetteville, and Route 3, Box 226, Eldorado, Arkansas.* *Received October 19, 1953*

NOTES ON THE CAPTURE OF TROPICAL BATS AT CUEVO EL PACHON, TAMAULIPAS, MEXICO

Recent collections from the arid tropical lowlands and humid mountain slopes in the Gómez Farías region of southwestern Tamaulipas have extended known northern ranges of such neotropical mammals as *Philander*, *Heterogeomys*, *Eira*, and *Mazama* (Baker, 1951; Hooper, 1953). A third account of the fauna of this region is in manuscript (Goodwin). The present report discusses further additions to the Tamaulipan fauna from Cuevo El Pachon and describes an unorthodox collecting experience.

All mammal specimens collected by the authors in 1950 and 1951 are in the American Museum of Natural History. Those taken by Robins, Heed and Martin in 1949 are part of the George M. Sutton Collection. For identifications we are indebted to Karl F. Koopman and Luis de la Torre.

Cuevo El Pachon lies in southwestern Tamaulipas, south of Gómez Farías, ten kilometers north-northeast of Antiguo Morelos and about two kilometers north of the Laredo-Mexico City Highway at Abra Pass. The mouth of the cave opens several hundred meters above the village of El Pachon, and is situated on the west slope of the Sierra Cucharas at roughly 200 meters elevation. Tropical Deciduous Forest is the characteristic vegetation type on this rough limestone mountainside; a bizarre arborescent member of the Liliaceae, *Beaucarnea*, is a dominant species. The cave is best known as the home of a blind Characin, *Anopichthys antrobius* (Alvarez, 1946), and the high ceilings above the pool inhabited by this fish are favorite bat roosts. In other areas, especially near the cave mouth, we have collected the frogs, *Syrrhophus* and *Eleutherodactylus*; a lizard, *Lepidophyma*; and a cave rat, *Neotoma*. Adjacent caverns, possibly part of a single cave system, have produced the faunal novelties *Tadarida femorosacca* at Paso de Abra (Dalquest and Hall, 1947) and a blind crustacean *Typhlolepidomysis* at Grutas de Quintero on the eastern side of the Sierra Cucharas (Villalobos, 1951).

On the afternoon of July 2, 1951, the authors closed the mouth of Cuevo El Pachon with

minnow seins, anticipating a bat drive into the nets from inside the cave after dark. By nightfall over one hundred bats, mainly the leaf-nosed bats *Artibeus* and *Glossophaga*, were flying in the main chamber adjacent to the entrance, but despite gunfire and other disturbance, none attempted an exit. Starting immediately at dusk, however, bats from outside the cave began to fly into the nets, some individuals making repeated attempts to "crash" the nets in their endeavor to enter. Within an hour 32 specimens were thus picked off the nets; 22 of these proved to be *Natalus mexicanus*, and the others *Chilonycteris rubiginosa*. As the nets employed were standard coarse mesh minnow seins, it seems improbable that the bats could not recognize such a crude barrier by echolocation. European bats observed by Vesey-Fitzgerald (1947) behaved in similar fashion, flying into brown paper placed across the mouth of their cave. On the basis of his extensive experience John W. Twente (personal correspondence) suggests that bats outside an occupied cave locate its mouth by following sounds emitted only by those within, and thus are unaware of artificial obstructions. Why *Chilonycteris* and *Natalus* sought entrance at twilight is not obvious to us, unless they drink from the cave pool, one of few sources of water in this porous region of coarse limestone.

Other field parties visiting El Pachon in the daytime have collected *Artibeus jamaicensis*, *Glossophaga soricina*, and *Desmodus rotundus*. A single individual of the hairy-legged vampire *Diphylla ecaudata* was shot March 13, 1949, by a group including W. B. Heed, C. R. Robins and P. S. Martin. On December 31, 1949, Bruce Hayward collected three specimens of *Natalus mexicanus* and noted a large number roosting inside, but neither *Natalus* or *Chilonycteris* appeared in our collection at El Pachon in 1950, or that of Heed, Robins, and Martin in 1949. Apparently the bats *Chilonycteris*, and *Natalus* represent additions to the known tropical fauna of Tamaulipas, although specimens of *Natalus* listed by Dalquest and Hall (1949) from "San Luis Potosi: 8 km NE Antiguo Morelos, 500 ft." may well refer to this locality in Tamaulipas.

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Marian and Paul S. Martin, *Museum of Zoology, University of Michigan, Ann Arbor.*
Received September 26, 1953.

ALBINO CHIPMUNKS IN RHODE ISLAND

In April of this year, in what is believed to be the first occurrence of its kind to be brought to the attention of interested zoologists in New England, a pair of adult albino chipmunks (*Tamias striatus lysteri*) were found in the countryside of South Kingstown, Rhode Island. Immediately upon discovery they were presented to the Zoology Department of the University of Rhode Island. These animals were caught exactly two weeks apart by a female house cat belonging to Avis Dawley, the daughter of a potato farmer in West Kingston, Rhode Island. Fortunately the cat had killed both chipmunks with minimal mutilation before depositing them at the back-door of the Dawley home. An examination of the presumed

burrow (beneath a large boulder about one-quarter of a mile from the farmhouse), revealed a recently occupied chipmunk nest but no signs of young.

The male albino was caught first. Both animals were typical albinos in possessing no pigmented external parts; the fur and vibrissae were entirely white, and the eyes were pink. Their measurements were about the same as those listed for the eastern chipmunk except that the female was nearly an inch shorter than the male. There were no pelage anomolies except color. The male bore several small scars around the head, some of them apparently quite recent.

Few notices and even less data are generally available concerning the appearance of albino mammals in nature. In the last fifteen years, mammal albino records from the New England and Middle Atlantic States include muskrats, woodchucks, deer, squirrels, porcupines and opossums. These are nearly all single reports of individual animals. Estimations of the appearance of an albino in a wild mammal population has varied from 1 in 10,000 for squirrels to 1 in 5,000,000 for buffalo. The chances of finding a breeding pair of adult albino mammals are certainly less. In this area of Southern New England small mammals are at the mercy of many enemies. The substitution of a brilliantly unharmonious white in place of the normal concealing or procryptic chipmunk coloration certainly decreases the probability of the attainment of maturity.—DONALD J. ZINN, *Department of Zoology, University of Rhode Island, Kingston.* *Received September 26, 1953.*

STORING OF FOOD ITEMS IN THE WINTER NEST OF THE ALASKAN GROUND SQUIRREL, *CITELLUS UNDULATUS*

There has lately been considerable informal discussion among biologists with a knowledge of the Alaskan ground squirrels on the question of whether these animals store any food in their winter dens. The only previous report on storing by this animal known to the author is given by William V. Mayer in his paper "A Preliminary Study of the Barrow Ground Squirrel, *Citellus parryi barrowensis*," (Jour. Mamm, 34:334–344, 1953), who did investigations on the dens of the ground squirrels of Barrow. It is therefore of some interest to report an instance of obvious storage observed in a ground squirrel nest on the Kotzebue Peninsula in 1951.

During a visit to the government reindeer herd at Kotzebue, Alaska, in the latter part of August 1951, I had the opportunity to make some observations on ground squirrels living in a steep sandy bank above the shoreline of Selawik Lake. One nest was dug out and the squirrel, an adult male, was captured. The nest was located in fairly dry sand 3–4 feet in from the surface of the steep bank. Tunnels, about eight feet in length, were dug in horizontally from the surface from two sides with the nest chamber lying about equal distance from each entrance. The nest was made of dry grass and was spherical in shape and about 25 cm. in diameter. On each side of the nest and close to both entrances was piled some plant material that was not an integral part of the nest and was obviously stored as food.

The stored material was kindly identified by Dr. A. E. Porsild, Chief Botanist, National Museum of Canada. It consisted of green leaves of willows, *Salix* sp., spikes of the crested cereal grass, *Agropyron latiglume*, and capsules containing ripe seeds of the rush, *Juncus balticus*. Although stored in the same place the three items were clearly separated from each other and did not constitute a fairly homogeneous mixture from all sources as was the case with the plant material used for the nest itself. This was taken as additional evidence supporting the hypothesis that they were stored for food.

However, from both places, the total amount stored was only about four double handfuls. This would of course not contribute very much toward the animal's total caloric requirement during the winter. On the other hand, if it was intended to be consumed shortly before or after the hibernation period of the squirrels or used as emergency food in case the animals waked up due to unusually low environmental temperatures, storing of this sort might be looked upon as being an important and integral part of these animals' successful adjustment to life in this type of habitat.—JOHN KROG, *Arctic Health Research Center, Public Health Service, Department of Health, Education, and Welfare, Anchorage, Alaska.* *Received November 9, 1953.*

THE BELDING GROUND SQUIRREL NORTH OF THE SNAKE RIVER IN IDAHO

When Howell (North Amer. Fauna, 56: 81, 1938) reported upon *Citellus beldingi* (Merriam), he indicated by a distribution map and by specimens examined that animals of this species were not known to occur north of the Snake River. Davis (THE RECENT MAMMALS OF IDAHO, Caxton Printers, Caldwell, Idaho; 168, 1939), stated that *Citellus beldingi oregonus* ". . . is confined to the region south of the Snake River." Hall (The Murrelet, Vol. XXI, No. 3: 59–61, 1940), in his original description of *C. b. crebrus*, included southern Idaho within its range. He listed no specimens examined, however, from north of the Snake River. To date, the concensus of opinion has been that the Snake River has acted as a barrier to the northward extension of the range of *C. beldingi*. On July 2, 1952, I found the Belding ground squirrel to be common in south-central Idaho, north of the Snake River. On May 28, 1953, eleven specimens were collected in Jerome County at the following localities: six, from 12 miles east of Hazelton; three, from one mile west of Eden; and two, from two miles west of Eden. These specimens are now in the Museum of Vertebrate Zoology, University of Utah. They represent a northward extension of the previously known range of *C. beldingi*. These aforementioned specimens are all from localities north of the Snake River and are indistinguishable from specimens of *C. b. crebrus* from south of the Snake River. Therefore, they are all referred to that subspecies.

Reference to the literature indicates that rivers and river basins are not often barriers to species of the subgenus *Citellus*. More frequently, it is noted that the soils on both sides of a river are occupied by members of the same species. Possibly these soils of the river basins act as avenues of dispersal for these squirrels. One explanation which might possibly account for the present distribution of *C. beldingi* is that formerly animals of this species occurred on both sides of the Snake River. Subsequently a "die off" may have occurred with differential effects on the two sides of the Snake River, and only recently has the population north of the Snake River replenished its numbers. An alternative explanation is that these animals have only recently gained access to the north side of the river. If either be true, it explains in part why former workers were not successful in collecting representatives of *C. beldingi* north of the Snake River.—RICHARD M. HANSEN, *U. S. Public Health Service Fellow, Microbiological Institute, Department of Vertebrate Zoology, University of Utah, Salt Lake City.* *Received October 9, 1953.*

THE BLOCK ISLAND MEADOW MOUSE, *MICROTUS PROVECTUS*

On May 15–17, 1952, the writer collected small mammals on Block Island, Rhode Island, to obtain a series of the indigenous species, *Microtus provectus* Bangs, 1908. According to Bangs' original description (Proc. New England Zool. Club, 4: 19–21, 1908) the island form is larger than the typical *Microtus pennsylvanicus* and the belly is always grey. Bangs noted peculiarities of the skull: "In old age the skull is longer and narrower than that of *M. pennsylvanicus*." Since a rough comparison of the two species did not reveal these differences, it seemed advisable to examine the material further.

Block Island is midway between Point Judith, Rhode Island, and Montauk Point, at the tip of Long Island, New York. It is approximately nine miles from either shore. The island is eight miles long and two to five miles wide. The topography consists of low rolling hills and many depressions which in some cases retain fresh water.

A pronounced ecological change has occurred on Block Island since Bangs collected there fifty-four years ago. He states: "It is under high cultivation, and is entirely without woods, or even trees, except for a few willows and poplars planted near some of the houses." A resident of the island, Miss Elizabeth Dickens, in recent correspondence relates that in 1900 Block Island was an agricultural section but "work went out of fashion."

The abandoned fields are dominated by bayberry (*Myrica pennsylvanica* Loisel.), blackberry (*Rubus* spp.), and beachplum (*Prunus maritima* Marsh.). In addition there are blue grasses (*Poa* spp.), strawberry (*Fragaria virginiana* Duchesne.), and cinquefoils (*Potentilla* spp.). The shores and beaches are provided with an abundant growth of algae on the glacial boulders and rubble.

Bangs mentions that mammals were not at all common on the island. Miss Dickens stated

that the rodent population increased noticeably with the change of habitat. The trapping success of the writer substantiates her observation.

Trap locations were dispersed over the island to sample a variety of habitats. A total of 43 specimens of *M. provectus* (21 adults and 22 subadults) was collected. I am grateful to Wm. A. Morris, Department of Lands and Forests, Ontario, for assistance with the field work on Block Island. For comparison, a series of 18 specimens of *M. pennsylvanicus* was collected in August, 1952, from Hunter, New York. The specimens from Hunter were taken under the auspices of the New York State Museum. Appreciation is expressed to Dr. Ralph S. Palmer for the use of this material. Conventional body and skull measurements were recorded in millimeters, and all measurements were taken by the writer. Only adult specimens were considered in the final comparison.

In Tables 1 and 2 the skull and body measurements are summarized for the samples from Hunter and Block Island. In addition Bangs' measurements are presented for comparison.

For any particular characteristic there is broad overlap between the ranges of the measured values in the Hunter and Block Island samples. With the exception of the measurement of the hind foot, there is an equally broad overlap between the ranges of measurements

TABLE 1.—*Skull measurements of samples of two populations of Microtus in millimeters*

Species	Statistic	Greatest Length	Zygomatic Breadth	Interorbital Constriction	Nasal Length	Maxillary Tooth Row
M. pennsylvanicus	Mean ± S.E.	27.4 ±.174	16.1 ±.142	4.2 ±.045	8.0 ±.099	7.0 ±.047
Hunter, N. Y.	Range	26.5–28.8	15.0–17.0	3.9–4.5	7.0–8.8	6.6–7.5
	No. specimens	16	17	18*	18	18
M. provectus	Mean ± S.E.	27.7 ±.131	16.7 ±.178	4.3 ±.062	7.8 ±.110	7.2 ±.065
Block Island, R. I.	Range	26.9–29.5	16.0–17.5	4.0–4.8	7.0–8.9	6.7–7.9
	No. specimens	18	19	19	19	19
	t	0.54	1.06	0.31	0.44	0.60
	d.f.	33	34	35	35	35
	P	0.33	0.25	0.55	0.19	0.24

TABLE 2.—*Body measurements of samples of two populations of Microtus in millimeters*

Species	Statistic	Total Length	Tail Length	Hind Foot
M. pennsylvanicus	Mean ± S.E.	173.9 ± 1.72	47.5 ± 1.08	20.5 ± .151
Hunter, N. Y.	Range	161–186	38–55	20–22
	No. specimens	17	17	17
M. provectus	Mean ± S.E.	171.8 ± 1.22	42.5 ± .622	21.5 ± .177
Block Island, R. I.	Range	161–182	37–48	20–23
	No. specimens	21	21	21
	t	1.23	3.85	1.74
	d.f.	36	36	36
	P	0.24	0.0006	0.09
M. provectus	Mean	175.2	47.6	22.4
Bangs' data	Range	166–187	43–54	21.5–23
	No. specimens	12	12	12

as given by Bangs and those of the Hunter and Block Island population collected by the writer.

Probability values indicate that there are no statistically significant differences between the two populations with reference to skull measurements, the total body length and the length of the hind foot. There is a highly significant difference between tail length measurements of the Hunter and Block Island specimens. However, the degree of overlap between ranges is such that it seems rather doubtful whether the two populations could be separated on the basis of this particular body measurement.

The anterior median projection of the interparietal is more prominent in *M. provectus*, and the nasals are square posteriorly. These differences were recorded by Bangs but intermediates definitely exist. A slight color variation is evident between the island specimens and those from Hunter. The dorsal and lateral color of the island form is lighter, the tail is more distinctly bicolored and the ventral surface is light grey to white in the axillary region. The Hunter specimens were taken three months later than the Block Island sample and this variation may be a seasonal one.

It seems apparent from these data that *M. provectus* is merely a subspecies of *M. pennsylvanicus*. Wheeler (Evolution, 4: 130, 1952) arrived at the same tentative conclusion after successfully mating the two forms.—J. L. Chamberlain, *Department of Zoology and Entomology, The University of Tennessee, Knoxville.* (Contribution No. 92) *Received October 22, 1953.*

THE FRACTION OF *PEROMYSCUS LEUCOPUS* FATALITIES CAUSED BY RACCOON ASCARID LARVAE

This paper presents a brief summary of cerebrospinal ascariasis in mice. Available data are utilized to estimate the possible significance of the disease in terms of fatalities among mice in nature.

Thanks are expressed to Dr. L. A. Stauber, Department of Zoology, Rutgers University, for his critical reading of the manuscript and for helpful suggestions. The writer is indebted to Dr. J. F. A. Sprent of the Veterinary School, University of Queensland, for permission to examine the latter's forthcoming review of ascarid life histories.

The report by Sprent (1953) that *Toxocara canis* and *Toxascaris leonina* can use intermediate hosts, makes infection via such an intermediate host appear clearly fundamental in ascarid life histories. Ascarid parasites of aquatic animals and of fish-eating birds still use intermediate hosts (Thomas, 1944). When the final host feeds in a medium that is essentially three dimensional (e. g., a body of water), then the parasite's survival is most likely if its larval stages occur in the food chain of the final host. Those terrestrial animals that are final hosts of ascarids are mostly ground surface feeders. Vertical dispersal is at a minimum on land, and the infective larva's probability of being encountered by the final host is correspondingly multiplied. Consequently, intermediate hosts of ascarids were less necessary to the survival of the worms following the adaptation of their primitive final host species to land life (Sprent, 1952). When the final host is a herbivore that feeds on grass and lives in large groups, no intermediate host appears to be needed. However, carnivores usually range over a larger area than do plant-eating species of comparable size and also form a less dense population.

Ascarids of terrestrial mammals have undergone various modifications whereby intermediate hosts have been omitted. Three of the carnivore ascarids have undergone another kind of specialization in that their larvae can invade the brain of rodents and grow large enough (one mm. or more in length) to cause fatalities (Tiner, 1953*a*,*b*). The diet of the raccoon is not as highly specialized as are the diets of many other carnivores. Its molar teeth have remained adapted to the grinding of mast. Consequently, the pathogenicity of the raccoon ascarid in the rodent brain may have evolved to a high degree of effectiveness for the following reason: the diets of other carnivores which are also hosts of *Ascaris* spp. (fisher, marten, badger, skunk, etc.) are known to include larger percentages of small mammals than do raccoon diets. These other carnivores should, therefore, tend to ingest

infected and non-infected members of intermediate host species, irrespective of whether larvae are present in their CNS or not. Raccoons would be expected to encounter chiefly those small mammals which have been exposed to larval *Ascaris* and which are not able to avoid a carnivore's close approach because of CNS impairments due to the presence of sufficiently developed worms.

The Central Illinois woodlots studied by the writer from 1947 to 1950 were heavily populated with raccoons, whereas skunks were scarce and badgers were absent (Tiner, 1953*b*). Larval ascarids found in mice and in squirrels taken from these woodlots most probably originated from the *Ascaris* of the raccoon.

A raccoon ascarid larva in the brain of a laboratory mouse is apparently always fatal (Tiner, 1953*a*). Preliminary experiments indicate that raccoon ascarid larvae are also highly pathogenic in the white-footed mouse *Peromyscus leucopus* (Tiner, 1953*b*).

Mice probably ingest eggs of carnivore ascarids accidentally during the course of feeding or while grooming themselves. If these eggs are properly embryonated and infective at the time of ingestion, they hatch in the intestine, and migrate to the lungs via the blood stream. Afterward, they most often encapsulate in skeletal muscles (Sprent, 1952). Larvae may leave the lungs by migrating directly outward into other tissues, or by entering the pulmonary venous blood. Although both exit routes are commonly used, the latter is the more significant because of its lack of simple reversibility. Those larvae that wander into or across the pleural or pericardial cavities should have a good chance to wander back into the lungs before they are trapped in connective tissue cysts. Those that enter the lumen of a vein, however, would seem to have a very small chance to exit from this same vein because the blood stream would sweep them into regions where the lumen is larger and where the traction or leverage obtainable from contact with the walls would be less. Also, the surface area of the pulmonary venous tree would be greater than the area of the visceral pleura.

Tissues and surfaces that are on or near the common ascarid migration pathway (intestine to liver to right side of heart to lungs) are subject to invasion by ascarid larvae before these larvae reach the lungs. These tissues are also exposed to ascarid larvae swept out of the thorax with the aortic circulation. All other tissues are exposed only to those larvae transported to them by the arterial blood. The numbers of larvae reaching each part are probably related to the volume flow of the blood supply to that part. There is no evidence that larval *Ascaris* with a minimum diameter of 30 μ would pass through capillaries and into venous blood. Once in the blood stream, ascarid larvae must usually become lodged in an arteriole or in a capillary and then push out into surrounding tissue spaces. However, larvae recently arrived in any part can probably re-enter the blood stream and be carried back to the lungs for a second excursion. Raccoon ascarid larvae are almost never seen in the abdominal viscera of fox and gray squirrels, possibly because those carried there by the arterial blood supply readily return to the lungs in the portal circulation.

A preliminary experiment was undertaken at the Merck Institute for Therapeutic Research. Three pairs of weanling rats were parabiosed, and then the larger and healthier member of each pair was given several thousand raccoon ascarid eggs with a stomach tube a week after the operation (a skin to skin union) had been performed. Two of the three undosed members of the pairs had raccoon ascarid larvae in the brain when the experiment was terminated. Under the conditions of the experiment, there was a small chance that unhatched and viable ascarid eggs passing out in the feces of the dosed animal were ingested by the other (undosed) member of the pair. Nonetheless, the most likely conclusion is that some larvae that arrive in skeletal muscle or subcutaneous fascia occasionally return to the lungs and subsequently reach the brain. The writer has observed that ten days or more after infecting, raccoon ascarid larvae are most often found in the brain of (laboratory) mice. The same is true of experimental raccoon ascarid infections in domestic and in cottontail rabbits (Tiner, unpublished data). We do not yet know what fraction of ascarid larvae developing in the brain arrived there after one or more preliminary excursions into other parts of the body.

The writer has observed that the central nervous system is about $\frac{1}{12}$ of the weight of the skinned and eviscerated carcass of weanling laboratory mice weighing 15 grams, and $\frac{1}{25}$

of the weight of the carcass of mature 30-gram white mice. A series of experiments (Tiner, 1951, 1952) has proven that the chance of a raccoon ascarid larva's developing in the brain is about one in 20 when it is ingested by a laboratory mouse. This proportion (1:20) was found to be independent of the dosage of larvae employed. In view of the gradual decrease in the relative weight of the brain as an animal matures, the proportion of larvae reaching the brain should decrease with the age of the mice. A value of 1:20 is intermediate between $\frac{1}{12}$ and $\frac{1}{25}$ and might apply to an average mouse.

If a group of experimental mice of uniform body weight were each given a fixed number of raccoon ascarid eggs, then the fractions of mice in the group that will have 0, 1, 2, . . . $n - 1$, and n larvae in the brain could be determined by using the binomial theorem $(a + b)^n = 1$ when a is the chance of an ingested larva's developing in the brain, b is the chance of an ingested larva's not developing in the brain, and n is the number of larvae ingested by an exposed mouse.

As the raccoon ascarid is apparently always fatal when in the central nervous system of mice, one interested in the probable mortalities need only be concerned with two classes of exposed mice—those without larvae in the CNS and those with such larvae. The first mentioned category is represented by b^n. The combined remainder is $1 - b^n$, or the fraction of exposed mice dying of ascariasis of the central nervous system. Should woodland white-footed mice prove to be significantly less susceptible to raccoon ascarid larvae than are laboratory mice, then a correction factor would be necessary in the values of a and b.

The problem of determining the percentile mortality of exposed mice in a natural population is also complicated by other facts. Wild mice would not be as genetically uniform as inbred laboratory strains. In addition, the numbers of infective eggs to which individual mice are exposed would vary widely. For these reasons, another type of mean, such as the harmonic or geometric might be better than the arithmetic mean, or possibly the median would be more appropriate. Any such change in the method of its calculation would give a lower value of n. More data are needed before an intelligent choice can be made between the preceding alternatives. Digestion of mouse carcasses with artificial gastric juice and counting of ascarid larvae in the residue would give a higher value of n than will result from only counting the visible encapsulations. It would also give a larger percentage of infected mice in a sample.

For convenience, we assume that the two kinds of error cancel one another and proceed with an n that is an arithmetic mean. A total of 61 cysts or larvae were observed in 14 mice from a total sample of 68 collected near Urbana and near Havana, Illinois (Tiner, 1952). One mouse contained a single larva in the brain and no larvae were visible elsewhere in the body. Except for its use in calculating a value of n, this mouse with a larva in the brain is excluded. Presumably, such mice would soon become fatalities should they not be trapped. Hence, the number of exposed mice is 13 in this paper, and the total number of mice in the sample is 67 instead of 68. The numbers of larvae observed in the individual infected mice were as follows: 2, 7, 20, 1, 1, 5, 2, 20, 1, 1, 1, 1, 2 and 1. Averaging of these gives a value of 4.7 for n.

If we designate the number of mice dead and therefore not trapped as x; the number of exposed mice in the sample, judged by their containing encapsulated larvae, as y; and the total number of mice trapped as z; then $\frac{x}{y+x}$ = fraction of exposed mice killed by ascarids. However, as stated previously, $1 - b^n$ = fraction of exposed mice killed when they were given n larvae each.

Since n was determined by averaging the number of cysts or larvae seen in the sample, z:

$$\frac{x}{y+x} = 1 - b^n.$$

The fraction of the whole population killed by ascaris is called w. $w = \frac{x}{z+x}$.

Substituting $b = 0.95$, $n = 4.7$, $y = 13$, and $z = 67$, we find that $x = 3.6$, and $w = 0.051$, or approximately 0.05.

This sample calculation using the available data indicates that about 5 per cent of the

white-footed mouse mortalities in Central Illinois woodlots may be due to cerebrospinal ascariasis.

This value is half the estimate of 10 per cent contained in a note published by the writer (1951) and appears to be more correct. Using the equations in the present paper, 10 per cent appears to be a larger fraction of the *P. leucopus* mortalities than would be caused by the raccoon ascarid in most natural environments.

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JACK D. TINER, *Veterinary Research Department, Merck & Co., Inc., Rahway, New Jersey.* *Received October 8, 1953.*

ZAPUS HUDSONIUS REPORTED FROM LEE COUNTY, ALABAMA

During June and July, 1953, I conducted a small mammal population study as a special investigation course in zoology at the Alabama Polytechnic Institute. The Alabama Cooperative Wildlife Research Unit cooperated in the study by furnishing transportation to and from the study area. In the course of this investigation, a jumping mouse, *Zapus hudsonius*, was taken four miles north of Auburn, Lee County, Alabama. A survey of the literature has been made and active mammalogists of the State have been contacted (Dr. Ralph L. Chermock, Associate Prof. of Biology, Univ. of Alabama, and Dr. Julian L. Dusi, Assistant Prof. of Zoology-Entomology, Alabama Polytechnic Institute. Personal communication). No previous records of *Zapus* have been recorded for Alabama. Several specimens of the jumping mouse have been recorded for Georgia, however, with one of these records being as far south as White Hall in Clark County, (Jenkins and Johnston, Jour. Mamm. 31, 461, 1951). Auburn, Alabama is approximately 150 miles southwest of White Hall, Georgia.

This specimen was a female, and the following measurements were taken: Total length, 182 mm.; tail, 116 mm.; hind foot, 34 mm.; ear, 9 mm. A standard museum skin was prepared and the skin and skull are deposited in the mammal collection of the Alabama Polytechnic Institute.

The capture site was an old field of about six acres which had been abandoned for approximately ten years. Half of this field was burned in March, 1953, in connection with quail management practices. The old field was located in a flat bottom along the edge of a small permanent stream. A fairly dense stand of vegetation from one to three feet tall and consisting mainly of partridge pea (*Cassia fasciculata*), broomsedge (*Andropogon* sp.), goldenrod (*Solidago* sp.), and greenbrier (*Smilax* sp.) covered the area. The surrounding terrain was composed of upland pine forests and mixed pine-hardwood forests. Trapping records in the old field showed *Peromyscus leucopus* to be by far the most abundant small mammal.

Special appreciation is extended Dr. Julian L. Dusi of the Zoology-Entomology Department, Alabama Polytechnic Institute for verifying the identification of this specimen.— EDWARD G. SULLIVAN, *R.F.D., Modoc, South Carolina.* *Received September 25, 1953.*

INSECTS IN THE DIET OF POCKET MICE, *PEROGNATHUS PARVUS*

Within recent years several investigators have drawn attention to the importance of arthropods in the diets of many kinds of small rodents. Sviridenko (1940), Hamilton (1941),

and Jameson (1952) pointed out that insects may comprise a large part, sometimes the major part, of the food eaten by forest-dwelling mice. Aldous (1941) and Tevis (1952 and 1953) included chipmunks among the rodents that may eat large quantities of insects. Other writers have mentioned, often with surprise, that rodents are not wholly seed-eaters, but may seek out insect food, sometimes neglecting food of vegetable origin.

Regarding the various species of pocket mice (*Perognathus*), published accounts are quite unanimous in asserting that they are strictly vegetarian; and some writers claim that pocket mice even shun food of animal origin. There are numerous workers who record many kinds of plants eaten by pocket mice; if compiled, the list would surely be an impressive one. There seem to be few observations of these mice having taken animal food. It is, accordingly, not inappropriate to call attention to the prominence insects may assume in the food of at least one kind of pocket mouse, *Perognathus parvus* (Peale).

In mid-April of 1951 twenty specimens of *P. parvus* were captured in a rocky sagebrush area on the eastern slope of the northern Sierra Nevada in Plumas County, California. From this series, 18 stomachs contained food. Of these 18 stomachs, 14 (or 78 per cent) contained some insects and 11 (or 61 per cent) contained only insects. The insects fed upon were almost entirely caterpillars; remains of other insects were present in small amounts. Three stomachs contained seeds. As indicated above, this differs from previous observations on the food of these little rodents.

To corroborate the data obtained from stomach analyses, I examined the cheek pouches of each mouse. Food was found in the cheek pouches of nine specimens: nine contained seeds, two contained insect pupae, and one mouse had pocketed a sprouting bud of bitterbrush, *Purshia tridentata*. This is much more in agreement with the data in published studies of pocket mice.

The difference between the contents of the stomachs and that of cheek pouches at once suggests that perhaps the latter do not present an accurate index to the diet of these mice. They are known to store large quantities of seeds and dried leaves and buds, and they doubtless use their pouches for transporting this material. It appears, however, that at times insects are eaten by pocket mice and may occasionally be their most important type of food.

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E. W. JAMESON, JR., *Department of Zoology, University of California, Davis.* *Received October 20, 1953.*

BLACK-FOOTED FERRETS USED AS CEREMONIAL OBJECTS BY MONTANA INDIANS

Four preserved black-footed ferrets (*Mustela nigripes*) were found recently in a collection of Indian relics at Pryor, Montana. The ferret skins had been collected and stuffed by Crow Indians many years ago and were used in ceremonies. The specimens were surprisingly similar to study skins but were decorated with colored cloth bands, ribbons, and feathers. The skulls were retained in the skins. Two small white-pelaged weasels (*Mustela* sp.) were included in the collection.

The age of the specimens could not be determined, but old Indians stated that they had been taken from the nearby Pryor Mountains on the Carbon-Bighorn County line in south central Montana. This is near the western limit of the recorded ferret range in southern Montana; the species is still observed occasionally in this locality. The relics formerly belonged to Chief Plenty-coups, a famous Indian leader who was a friend of the whites. The number of specimens present suggests that Indians were aware of the rarity and distinct appearance of the species and attached a mystic significance to it.—Liven A. Peterson and Elihu D. Berg, *U. S. Fish & Wildlife Service, P. O. Box 1381, Billings, Montana. Received October 18, 1953.*

BLACK-FOOTED FERRET IN SOUTH DAKOTA

Information supplied by George Barnes, Senior Mammal Control Agent of the U. S. Fish and Wildlife Service, Custer, South Dakota, led to the capture of five black-footed ferrets. The animals were taken from a recently poisoned prairie dog town located two miles west of Midland, Haakon County, South Dakota. A sixth ferret was seen here but was not trapped.

All ferrets (*Mustela nigripes*) were captured within an area 150 by 50 yards. They were all full grown but a study of tracks and the distribution of the burrows within which they were found indicated that it was a family group with a litter of four. No close examination of the animals was made but it is believed three were males and two were females.

One female ferret died in the traps. This carcass was preserved by freezing and contributed to the National Museum in Washington, D. C. Another ferret, a male, had been severely injured on the back before his capture and died soon after he was caged. Only his skull was saved.

A male and a female ferret were released in Wind Cave National Park to establish the species in that protected area. The remaining animal was held in captivity until December 30, 1953, when it was released in Wind Cave National Park.—W. E. Garst, *Douglas, Wyoming. Received October 18, 1953.*

LEAST WEASEL IN GLACIER NATIONAL PARK

On July 23, 1953, Ranger Paul Webb saw a least weasel (*Mustela rixosa*) dart in front of a car just inside the Glacier National Park boundary on the Two Medicine Road. The weasel was carrying a young in its mouth. The car struck the female killing it instantly, but the young was thrown clear and unharmed. The skull of the female was completely smashed and could not be saved, but the skin is now number 298 of the Glacier National Park study skin collection.

This is the first record of the least weasel from Glacier National Park.—R. R. Lechleitner, *Ranger Naturalist, West Glacier, Montana. Received September 22, 1953.*

WOLVERINE SEEN IN SQUAW VALLEY, CALIFORNIA

On the morning of July 22, 1953 while conducting a field trip to Squaw Valley, Placer County, California, elevation 6100 feet, a wolverine (*Gulo luscus*) was observed by about 25 persons enrolled at the Audubon Camp of California, Norden, California.

The wolverine was observed in a meadow of approximately four acres in the midst of a lodgepole pine (*Pinus contorta*) and Jeffrey pine (*Pinus jeffreyi*) stand about a quarter mile inside the entrance of Squaw Valley. When first seen it was walking slowly about in the midst of an extensive yellow-bellied marmot (*Marmota flaviventris*) colony. When we got out of our station wagons, which stopped 150 yards away on the road into Squaw Valley proper, the wolverine became alarmed and ran off up a slope into an area of large granite boulders embedded in the terminal moraine of this glaciated valley. It ran with an undulating gait much like that of an otter or marten. From our point of observation the wolverine appeared to be about one-half again the size of a full grown badger.

The party approached the area where the animal had first been seen. There I found tracks and what may be the scat of the animal. It is in two pieces. One measures 80 mm. in length by 16 mm. in width at the widest place. The other is 43 mm. by 22 mm. The scat contains

the hair and claws of what appears to be a Belding squirrel (*Citellus beldingi*) or Beechey ground squirrel (*Citellus beecheyi*), both common in the area, with the Belding squirrel being more abundant. Some of the tracks had five toe marks with claws showing and others had four. The tracks were in dust. They resembled wolverine tracks as shown on page 64 of MAMMALS OF CALIFORNIA (Ingles, Stanford Press, 1947) but were larger. Ingles' caption indicates that the tracks shown in his book are about one-half size.

In six seasons of ten weeks each of field work in this area, this is the first wolverine that we have observed.

The field leaders of this party, all of whom saw the wolverine and agree as to its identity were: Dr. Joel Gustafson, San Francisco State College, Mr. Robert P. Hays, Pasadena City College, and myself.—FERDINAND S. RUTH, *Biological Sciences, East Contra Costa Junior College, Concord, California. Received October 13, 1953.*

INCISOR TOOTH WEAR IN THE SEA OTTER

Lower incisors of sea otters often become much worn on their anterior surfaces in a plane perpendicular to the chewing surfaces of the cheek teeth. The four incisors are evenly reduced to the same level regardless of individual angle or protrusion. The upper incisors remain unworn and do not reach the smoothened faces of the lower teeth. All canines become worn at their tips, but the lower ones may also be abraded on their forward surfaces. It is evident that the relatively procumbent lower incisors, and less frequently the canines, are worn down when the mouth is open, and that the abrasive agent is outside of the mouth rather than within the jaws.

Fifty-four skulls having at least some unbroken upper and lower incisors were examined; the wear described was found in both northern and southern sea otters, and in animals of each sex. Incisor wear was evident in 32 of 40 skulls classed as adult on the basis of large size, sagittal crest development, or wear of molar teeth; the lower canines were abraded in 9 of these heads. Incisor tooth wear was slight or absent in young animals.

Mollusks comprise about 10 to over 40 per cent of food eaten by the northern sea otter (Jones, Trans. Sixteenth N. A. Wildlife Conf., 1951; Murie, Jour. Mamm., 21: 119–131, 1940). Apparently mussels, limpets, and chitons are dislodged by scraping and prying with the lower teeth while the mouth is open, neck muscles probably aiding jaw muscles in drawing the head forward. The traces of bryozoans, barnacles, pebbles, coral fragments and dirt reported from stomach analyses may be taken incidental to removing reluctant shellfish from their substrate in this manner.

Fisher (Jour. Mamm., 20: 21–36, 1939) found that the southern sea otter eats many abalones and figured three shells showing "broken places characteristic of all taken by the otters." She said the shells might be broken by the strong canine teeth, but states "It is still unknown just how the otter detaches the large abalones from the rocks with their small paws." Sea urchins are procured with the forepaws, but it is probable that the teeth are used to dislodge abalones and that the shells are broken in the process. The cracked portion of the shell is about the size and shape of the otter's bite. The edge of the shell adjacent to the siphon pores seems to be attacked more often than the opposite margin in spite of the presence there of an inflected flange of shell; that edge is more nearly vertical to the rocks and would permit the lower canines of the otter to pry or bite without slipping. With the tips of the canines thus engaged the anterior surfaces of the lower incisors and canines might be abraded against the rocks to produce the wear noted.

The author is indebted to D. C. Hooper of the Fish and Wildlife Service for critical comment, and to the curators of the following collections for making skulls available for study: Amer. Mus. Nat. Hist.; Calif. Acad. Sci.; Mus. Vert. Zool.; U. S. Biological Survey; U. S. Nat. Mus.—MILTON HILDEBRAND, *Department of Zoology, University of California, Davis. Received October 10, 1953.*

GREEN ALGAL GROWTH ON GRAY SEALS

An unusual plant-animal relationship was observed during the fall of 1951 in the Miramichi River estuary, New Brunswick, while collecting gray seal (*Halichoerus grypus*)

specimens for the Fisheries Research Board of Canada. Similar associations were reported for crippled or pregnant harbour seals by Scheffer and Slipp (Amer. Mid. Nat., 32: 381, 1944). A fisherman, Fred Ross, with whom the seals were hunted during the summer and fall, mentioned obtaining some individuals "with green moss on their backs" in previous years. Of five seals taken during August of 1951 none were so affected, but two of three pregnant females taken during the autumn, on September 28 and October 11, exhibited this phenomenom. No other seals were taken at this time.

In the water these seals appeared to have a dense mass of long green hair waving from the dorsum. After removal from the water the material lay quite flat and was not so conspicuous as when roughed by the hand. Closer examination showed that the growth consisted of many strands of green algae attached to the outer parts of the guard hairs by minute holdfasts. The length of these algal strands was from a few millimetres to nine inches. The elliptical areas affected on the seals were roughly *36″* x *6″* on the specimen taken September 28, and *48″* x *8″* on the seal taken October 11. The strands were much less dense towards the periphery of the patch, as if it were spreading gradually from a central spot where it first became established.

The alga has been identified by Miss Constance MacFarlane of the Nova Scotia Research Foundation as *Enteromorpha groenlandica*, a common species in the Maritimes. She adds: "It flourishes when kept wet and cool—but on rocks where it is abundant near high water mark it disappears rapidly following one or two hot sunny days." This is a possible reason that it was found on seals in the autumn but not in the summer of 1951, as most of the herd will lie out all day if not disturbed. However, in previous summers Mr. Ross has taken some seals with the growth, so it is believed more likely that it occurs on only a small proportion of the herd at any time. While the gray seals are in the Miramichi estuary, from July till November, they spend much time hauled out on sandbars, as long as they are undisturbed, and most of them are completely out of water, often for several hours. Some, however, lie at the water's edge with the waves washing over them and this situation would favour the growth of algae.—B. A. Mackenzie, *Atlantic Biological Station, St. Andrews, N. B. Received October 28, 1953.*

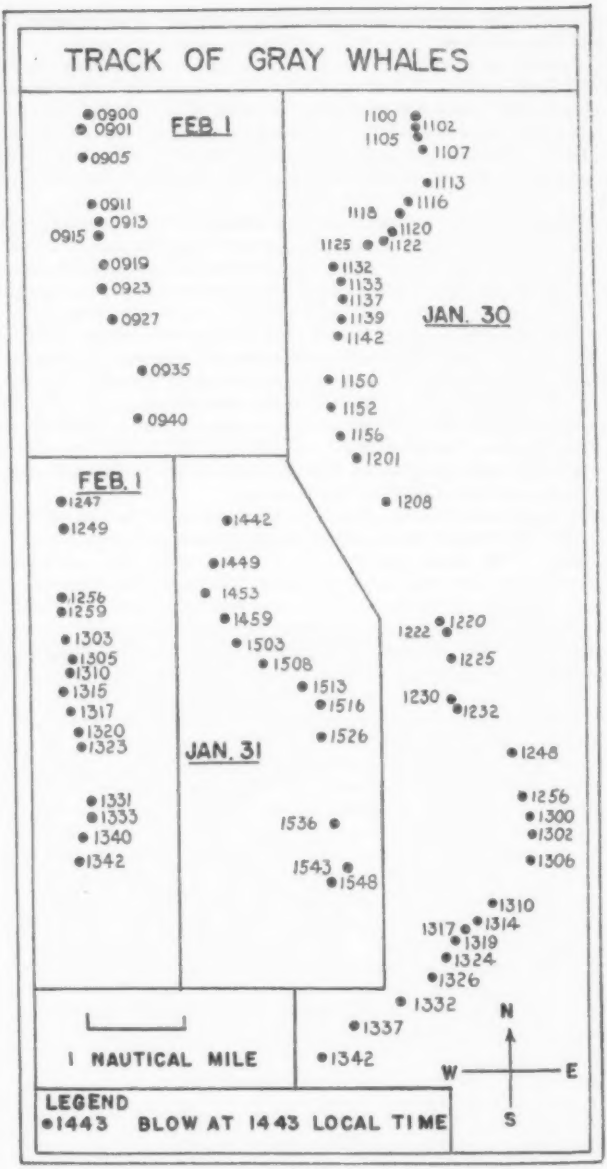
OCCURRENCE OF *ZALOPHUS CALIFORNIANUS* IN THE GULF OF CALIFORNIA

Townsend (1899, U. S. Treasury Dept., Doc. 2017, Div. of Special Agents, pt. 3; pg. 268) reports ". . . sea lions (*Zalophus californianus*) along both coasts of Lower California, and they inhabit also the Tres Marias Islands." Townsend's investigations appearantly included little more than the entrance and nothing of the northern part of the Gulf of California. Nelson (1899, N. Amer. Fauna, 14: 17–18) also reports the presence of *Zalophus* on the Tres Marias group. Both Nelson's and Townsend's reports are based on sight observations.

In the spring of 1953 two skulls of *Zalophus californianus* were presented to the University of Arizona through the courtesy of Dr. John F. Lance. The first of these was an adult female (identified by Dr. Robert T. Orr, Calif. Acad. Sci.) from Cholla Bay, three miles north of Punta Penasco, Sonora, Mexico. The second is an incomplete skull of a young adult from Guaymas, Sonora, Mexico. Reports indicate these pinnepeds are plentiful within the Gulf. No large rookeries are known but at least one small rookery at Rocas Consag (55 miles west of Punta Penasco) has been photographed.—Robert B. Chiasson, *Department of Zoology, University of Arizona, Tucson. Received September 18, 1953.*

OBSERVATIONS ON THE MOVEMENTS OF THE PACIFIC GRAY WHALE *ESCHRICHTIUS GLAUCUS* (COPE)

Through the courtesy of the Scripps Institution of Oceanography a party from the Woods Hole Oceanographic Institution was able to conduct a study of the Pacific gray whale, *Eschrichtius glaucus* (Cope), off San Diego, California, during its annual southerly migration. The R/V horizon was made available for this work during the period January 28–February 2, 1952. As a part of the over-all study a running plot of the movements of indi-


TRACK OF GRAY WHALES
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0940
JAN. 30
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1102
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1107
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1116
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1120
1122
1125
1132
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1137
1139
1142
1150
1152
1156
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1208
FEB. 1
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JAN. 31
1536
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1342
1 NAUTICAL MILE
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LEGEND
1443 BLOW AT 1443 LOCAL TIME

FIG 1

vidual whales and of the ship was maintained by an observer on the HORIZON. This plot is presented and discussed here.

The area of operations was bounded on the north by the latitude of Point La Jolla, on the south by Point Loma, and on the east by the western edge of the kelp beds, which corresponds roughly to the twenty fathom curve; the width of the whales' "flyway" here appeared to be not much more than a mile. As pointed out by Dr. Carl L. Hubbs, many whales in their southward movement converge on the kelp beds off Point La Jolla. Accordingly it became our practice to lie just off these beds, then pick up passing individuals, and follow them south.

Four runs of between forty minutes' and two hours and forty minutes' duration were made on separate whales—one on January 30, one on January 31, and two on February 1. The plots of these runs appear in Figure 1. To avoid confusion, the ship's track has been omitted. Each dot represents a sighting of a whale at the first blow after a long dive.

This plot suffers from two basic weaknesses. First, it is a dead reckoning plot, based on courses steered by the gyro compass and on speed determined from the shaft revolutions. An average visibility of about 1500 yards in the seasonal fog prevented taking visual bearings on landmarks on the beach for determining geographical location. The second weakness lies in the method of plotting the position of the whale relative to the ship. Visual bearings taken on the first blow after the long dive are accurate to plus or minus one degree. The ranges were estimated by "seaman's eye", and occasionally checked by ultrasonic echoranging. These ranges varied from 200 yards to 900 yards. The possible range errors are probably consistent, for one observer did all the plotting.

The speeds averaged over each run were 4.5, 4.6, 4.6, and 4.6 knots. The lowest speed made good in a straight line between blows was 2.4 knots, occurring between 1256 and 1259 local time on February 1. The highest speed between blows was 6.5 knots, measured between 1208 and 1220 on January 30. This period represents the longest dive observed. Although it was foggy, with visibility of 1500 yards, the sea was very calm. While the possibility exists that a blow was missed, the presence of at least two lookouts in addition to the plotter makes this possibility seem remote. Andrews (Mem. Amer. Mus. Nat. Hist(N.S.), 1: 227–287, 1914) states that the gray whale averages about three or four knots when cruising along the shore, and that its maximum speed is seven or eight knots when badly frightened. Walker (Nat. Hist., 58: 248–256, 1949) gives a cruising speed of "six or seven miles per hour" as the average for the migrating whales off La Jolla.

It is felt that this average speed of about 4.6 knots represents a cruising speed of the whale. It was our observation that as long as the HORIZON stayed about ¼ mile away from the whale that we were following, the behavior of that individual was not noticeably differernt from that of others observed at greater distances. However, two of our maneuvers did disturb the whales. First, when the HORIZON came within 200 or 300 yards ahead of the whale, the whale was seen to veer off to the east or west until well clear of the ship, and then resume its normal southerly movement. Second, when ½ lb. blocks of tetryl-TNT were detonated in the water within about 500 yards of the whale, the whale usually maneuvered so radically that it was not sighted again.

The period of the breathing cycle of the whale as observed here was ordinarily between four and five minutes. The cycle usually consisted of three quick blows followed by a long dive. The vapor from the first blow after the long dive was the most dense, hence most easily spotted. The number of blows agrees with Andrews (1914), who reported a period of from seven to eight minutes for the complete cycle when the whale was cruising along shore, and a period of four or five minutes for a female on a straight course.

In conclusion the author would like to express his thanks to the Scripps Institution of Oceanography for the opportunity of conducting this study, in particular to Mr. James M. Snodgrass for his many efforts in arranging details, and to Captain Noel L. Ferris and the officers and crew of the HORIZON for their excellent cooperation.—RALPH F. WYRICK, Contribution No. 672 of the Woods Hole Oceanographic Institution, *Woods Hole, Massachusetts*. (This work was performed under Contract No. NObsr-43270 with the Bureau of Ships, U. S. Navy Department.) *Received November 1, 1953.*

DICHOTOMOUS FORKING IN THE ANTLERS OF WHITE-TAILED DEER

The antlers of mature white-tailed deer (*Odocoileus virginianus*) and mule deer (*O. hemionus*) normally are easily differentiated by the type of branching, the former being characterized by individual tines projecting vertically from a single main beam, whereas in the latter species forking is dichotomous, the main beam dividing and each branch further subdividing. Young mule deer bucks, in the 2–4 year age class, sometimes bear three tines on a main beam, in the manner of white-tails of like age, but fully adult racks of the two species are usually distinctive.

In April of 1953 I encountered a population of white-tailed deer in which some of the adult bucks bore dichotomously forked antlers that, but for their small size, might easily have been produced by mule deer. In company with Alden H. Miller and Ward C. Russell of the Museum of Vertebrate Zoology, I was camped for approximately a month in the Carmen Mountains of northern Coahuila, Mexico. During this period we collected vertebrate specimens from Carboneras, Corte Madera, Botellas, and Boquillas canyons, and from the intervening ridges, at elevations between 5000 and 8000 feet. White-tailed deer were generally numerous in the region and we took four specimens and saw many more. This population of deer has been given the name *O. v. carminis* by Goldman and Kellogg (Proc. Biol. Soc. Wash., 53: 81–90, 1940) based on two specimens collected in Botellas Canyon.

Among the cast antlers that were encountered here and there on the ground we picked up three that were dichotomously forked (Fig. 1) and the skull of a lion-killed buck showed an intermediate type of forking on one side, two tines being joined for an inch or so where they attached to the main beam. The majority of the cast antlers were of normal form for white-tails, but most of them were from younger animals. Considering only the large antlers from fully adult males, a substantial proportion showed a tendency toward dichotomous forking. Unfortunately no records were kept of actual numbers of antlers in the various form classes. Mule deer (*O. h. crooki*) occur in foothill areas of northern Coahuila but not in the higher

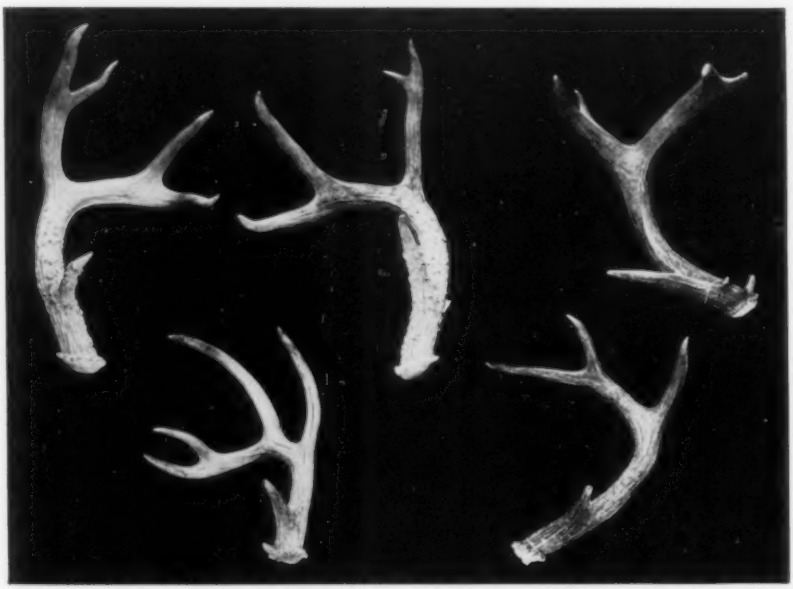

FIG. 1.—Three antlers of white-tailed deer from the Carmen Mountains showing dichotomous forking, and two "normal" antlers from the same area.

reaches of the Carmen Mountains. There was no chance that the antlers here described could have come from any other deer than the local whitetails.—A. STARKER LEOPOLD, *Museum of Vertebrate Zoology, University of California, Berkeley. Received November 15, 1953.*

REVIEWS

Simpson, George Gaylord. THE MAJOR FEATURES OF EVOLUTION. Columbia University Press, New York City, New York. xx plus 434 pp., 52 figs., 28 tables. 1953. Price $7.50.

This new book by Simpson is based upon his previous Elliot Medal winner, TEMPO AND MODE IN EVOLUTION, which was his attempt to interpret the fossil record in terms of population genetics and to extend the validity of genetics by its application to the fossil record. As Simpson has pointed out, his earlier book aided in the movement of molding the data from paleontology, systematics, genetics and other life sciences into a synthesis on the principle of evolution. The past decade has brought forth more revolutionary knowledge of evolution than developed in all preceding time. Therefore, Simpson felt that another book which would synthesize both the findings of his earlier book and the knowledge acquired during the past ten years was necessary. The real objective of this new work is an attempt to interpret the fossil record in light of the new knowledge acquired in the fields of population genetics and systematics.

The book contains 12 chapters entitled: Rates of Evolution, Morphological Rates; Taxonomic Rates of Evolution; Variation; Mutation; Population and Selection; Adaptation; The Evolution of Adaptation; Trends and Orientation; Extinction, Relicts and Irreversibility; Horotely, Bradytely, and Tachytely; Higher Categories; Patterns or Modes of Evolution.

This list of chapter titles will inform the reader that the bulk of the book is dedicated to the analysis of the various factors and elements of evolution. In each, there is an attempt, and I might say, a very good one, insofar as possible to synthesize the data from all other fields and bring them to bear upon the factor under consideration. This has caused some considerable, although not unnecessary repetition in some sections. Simpson points out the well known fact that analysis of each component of a problem is necessary, but cautions that this can also become hazardous to the overall understanding of the whole problem, especially one so complex and yet so unified as that of evolution. To my point of view, Simpson has done, however, a remarkable job in taking the data from paleontology, morphology, taxonomy and population genetics, and developing an understandable synthesis of these facts upon which the basic principles and the course of evolution are predicated. This book is outstanding, and is, insofar as I am aware, the only one that has successfully made an outstanding contribution from the standpoint of the aforementioned synthesis. The book is extremely well documented, and one is somewhat amazed at Simpson's grasp of the literature in all languages in this subject. Personally, I consider one of the major contributions of this book to be the 17 pages of "Works Cited." These pages contain the majority of all pertinent references on this subject. Therefore, a copy of THE MAJOR FEATURES OF EVOLUTION must be on the shelves of all serious students of evolution.

In a prefatory statement, Simpson stated that in this book he was not a "Paleontologist," but a student of "four dimensional biology". Nevertheless, the bulk of his factual material in each section is from the field of fossil vertebrates. There are some data from the invertebrates and plants. While statistical formulae are lacking, the major part of the treatment and interpretation of the data is statistical, and quantitative analyses play a large role in the development of the principles. The illustrations are sufficiently numerous, and are well chosen to explain the points in question.

Space precludes a critique and analysis of each chapter, although each merits it. In general, the chapter is opened with a presentation of the facts and an expression of the concepts and principles. Most chapters are in the argumentive style, setting forth the various facets of the question, followed by an enlargement with fact and inference in support of the view held the most tenable by Simpson.

Simpson is a Neo-Darwinian, and throughout his book, he has ably championed the position that combinations of small genetic changes, and their selection under natural conditions, are the real forces in evolution in the development of new forms. In this, he is diametrically opposed to the great geneticist Goldschmidt and the paleontologist Schwindewolf, who sponsor the hypothesis of macromutations as opposed to the accumulations of small mutations in accounting for the changes of evolutionary worth. Simpson has bearded them in their own dens, and by means of statistics, the laws of probability, the facts from the fossil record, and by logic and inference, has just about relegated their mutationist hypothesis into obsolescence. In his discussion of higher categories, Simpson has shown conclusively that the large apparent discontinuities between the higher categories are more imagined than real, and that in each case where materials from the intermediate time or zone have been recovered, they bespeak of a continuum, which negates the hypothesis of Goldschmidt and Schwindewolf in accounting for the discontinuities. In all this, Simpson is not dogmatic, and does recognize that in some cases single large mutations may have accounted for some few significant events.

In his treatment of orthogenesis, Simpson has shown that it is fictitious as an end product of an internally directed force. Moreover, he has demonstrated that there was a significant amount of variation in the classical examples of orthogenesis, e.g. *Megaloceras*, *Gryphae*, etc. He explains the event of orthogenesis on the Darwinian principle of natural selection, as an example of narrow adaptation.

The last sections of the book containing the best attempts at synthesis are extremely informative, and bring the various analyses into a meaningful unification. Being a neontologist, I was pleased to find that here, for the first time, I was actually observing a paleontologist giving a dynamic concept to evolution by studying the individual organisms, their populations, genetics, ecology, adaptations, rates of change, etc., rather than merely expounding upon it in terms of the relatively static taxonomic categories. One gathers the impression that Simpson is starting his analysis of the problem at the level of the animal (which is the only tangible thing after all), and not at its assigned taxonomic position. Simpson has noted in several places, that irrespective of the taxonomic category under discussion, it must be remembered that the beginnings of all categories are in the individuals, back at the level of the species and subspecies.

The text lacks an adequate discussion of the gene pool with its additions, mutations, recombinations and deletions, with reference to its differential activities concerning the lower taxonomic categories. I had hoped to find discussions on such questions as: Are mutations, or true additions to the gene pool, really operative at the level of the subspecies, or is this the result of merely reshuffling the genetic deck? At what taxonomic level do true mutations really express themselves? Does gene mutation have significance in a population in the development of a new kind below the level of the species? To me, this type of information is basic, because here we are at the crux of the problem of what happens to the animal. Here is the beginning of all taxonomic categories, and we can only progress in our understanding of the whole problem of evolution in proportion to our understanding at this level.

I found few errors in the book. The style of writing is generally complex and somewhat difficult. The sentences are long, involved and many are encumbered with parenthetical statements. In some places, the exact meaning is still not clear to me. To reiterate, the book is excellent and both Doctor Simpson and the Columbia University Press are to be congratulated for preparing another milestone in this field.—Stephen D. Durrant, *Department of Zoology, University of Utah, Salt Lake City.*

Hill, W. C. Osman. Primates: Comparative Anatomy and Taxonomy. Vol. I: Strepsirhini. Edinburgh University Press, xxiii + 798 pp., 34 pls., 199 figs. 1953. Price £5:5s.

There does not exist for any order of mammals a monograph fully reviewing its current biology. Non-primatologists, long inured to this deficiency in their own special fields, may be surprised to learn that this is true also for the seemingly over-studied order Primates. The two works which have had to serve in some degree are Forbes' handbook (1894) and Elliot's review (1913). These works, however, are about half a century behind current

needs, and Dr. Hill, in his preface to the volume under review, modestly cites their antiquity as a partial justification for his monograph. Actually these two works, even in their day, were not definitive, since they dealt with only the most superficial taxonomy and the briefest natural history; and only the older one even cataloged the fossil forms then known. Dr. Hill's plan, with its first fulfillment in this volume devoted to the lemurs, galagos and lorises, is for a much more comprehensive work, covering not only taxonomy and comparative anatomy, as the title indicates, but also a treatment of development, physiology, behavior, ecology, and paleontology, insofar as the literature and his own researches make it possible. The only work at all comparable in scope, but on a much more limited scale, is Wood Jones' MAN'S PLACE AMONG THE MAMMALS (1929).

The work is taxonomically organized, with a review at each hierarchical level, of the relevant history, structure, reproduction, development, behavior, distribution and taxonomy. The index, with main entries in boldface type and illustrations indicated by asterisks, helps to locate the level at which one will find various features in this necessarily complex and somewhat repetitive scheme.

The taxonomy is mainly dedicated to expediting the identification of material, and omits nomenclatorial controversies and exhaustive synonomies. In all, 98 subspecies ("relegated to small type so as to avoid embarrassment to the seeker after purely general or morphological information") and 139 species (31 living and 98 fossil) are treated. These constitute 17 living and 41 extinct genera. All but three of the living genera are illustrated in the 44 plates by either a living or mounted specimen or a skeleton, and in some cases by both. The generic categories *Altililemur* and *Myoxicebus* are absorbed in *Cheirogaleus*, and *Mizocebus* in *Lepilemur*; *Euoticus*, *Galagoides* and *Phaner* are given generic distinction. The name *Avahi* is given precedence over *Lichanotus*. The Cheirogaleinae are ranked as lemurs but their lorisoid features are pointed out. Fifteen maps give the distribution of all but eight of the living species.

The higher taxonomic categories adopted are inevitably controversial. The tupaioids are not granted primate status, though five families of fossils, perhaps more divergent from the adopted definition of the order, are included. The lorisoids and lemuroids are given subordinal rank and grouped under a grade Strepsirhini. The tarsioids are removed from this grade as set up by Geoffroy, and grouped with the platyrrhines and catarrhines as the Haplorhini. This bipartite division of the order, originated by Pocock and championed by Wood Jones, has not been generally adopted. It is based on characters of the rhinarium which are regarded by many as of insufficient significance, of too limited applicability since unknowable in fossil forms, and contradictory to the ever growing paleontological evidence of the fundamental similarity of the tarsioids to the lemuroids. Many readers would doubtless have preferred that this work, destined for so long and universal reference, had used the more common and non-committal tripartite division of the order, leaving to the future the assignment of the controversial tarsioids.

The bulk of the volume is anatomical, presenting a vast compendium from the widespread literature and unpublished studies of the author and others. The fullest treatment is given those subjects most indebted to the original researches of Dr. Hill—alimentary tract and external features, including genitalia—and more than half of the 199 text figures are devoted to them. Another third of the figures illustrate skulls; remaining ones are of muscles and brains.

A large variety of readers will long be thankful to Dr. Hill for his arduous labors in assembling this useful reference work and organizing it with more common sense and functional perspective than the usual cataloging type of source. Since he has accomplished so much it may seem ungracious to complain that he has not done more, but the author has felt, he tells us in his preface, the need of a compendium "in which the gaps in our knowledge could be readily detected". This would presume a degree of completeness all but impossible for a single worker to achieve, and Dr. Hill nowhere claims to have done so. He does, however, inform his readers that this work "is the immediate outcome of the need expressed above" and it would be unfortunate if it were then assumed that the sizeable gaps in the

book necessarily represent real lacunae in the published field. (There is next to nothing on the peripheral nervous system, for example, and some excellent papers written on various subjects during the past few decades are missed while superseded nineteenth century ones are quoted.) A general statement of what he felt he had accomplished, what he had not attempted, and, from his perspective, what areas are most urgently in need of study would have made his book even more helpful.

This large, handsome volume represents a milestone in the history of primatology. For the first time a man with the requisite grasp, energy and courage has undertaken the overwhelming task of gathering the widespread fragments of the subject into an organic whole. That he should miss some items and misconstrue others is inevitable in so vast an undertaking; it is really surprising that there appear to be so few. This is bound to become the standard reference work on the primates providing a guide and stimulus to a wide variety of workers who eagerly await the succeeding volumes.—G. E. Erikson, *Department of Anatomy, Harvard Medical School, Boston 15, Massachusetts.*

Bourlière, François. The Natural History of Mammals. Alfred A. Knopf, New York. xxi + 363 + xi pp. Illus. 1954. Price, $5.00. (Translated from the French by H. M. Parshley.)

This work in the French edition (vie et moeurs des mammifères) has previously been reviewed in this Journal (Hamilton, Jour. Mamm., 32: 478). However, the publication of an English edition makes this valuable book more widely available and the contained information more easily accessible. In the translation, the book has been revised and new material added to make the work more comprehensive and less regionally restrictive in its coverage.

Such a book as this has a special value in giving a perspective of the natural history of mammals on a world basis, an outlook often lacking in more regionally restrictive accounts.

There are ten chapters in the book, each giving an admirable summary of particular aspects of the natural history of mammals. The extensive coverage of recent American literature will be revealing to many readers.

It is not unexpected that lack of personal familiarity with American forms should lead to some errors of fact or interpretation as, for example, when it is stated that beaver houses are always surrounded with water (p. 91). However, calling a muskrat house a "hibernation lodge" (p. 91) is not easily excusable, or is the unqualified statement that . . . "deer mice, Pacific kangaroo rats, and Wyoming pocket mice" . . . are hibernators (p. 86).

Despite such occasional lapses the book is one that will reward every mammalogist that reads it. The paucity of our knowledge on many phases of mammal life is starkly revealed by the author's discussions and the book will certainly serve to stimulate further research.

The book is illustrated with carefully selected halftones, and with many line drawings by Paul Barruel that serve to supplement the text very successfully. Additional features are a taxonomic list of species, accompanied by common names; an extensive classified general bibliography; special bibliographies arranged by chapters; and an index.

Dr. Bourliere has made a fine contribution to current mammalogical literature and one that should be read by all mammalogists.—W. Robert Eadie.

Walker, Ernest P. The Monkey Book. The Macmillan Company, New York. 153 pp., 51 pls., 1 fig. 1954. Price, $6.50.

This book reflects the great affection the author holds for his charges in the National Zoological Park, Washington, D. C. No one who has heard him talk about them can doubt the sincerity of this affection and all who read this work will be convinced of it.

An outstanding part of the book is the collection of fine plates, many from photographs by the author, that illustrate the appearance and external characters of most of the genera of living Primates. Some of the illustrations of the rarer forms are taken from the works of the older naturalists and have a special interest of their own.

The first part of the book discusses in detail the facts of monkey care. That this information comes from direct, personal experience is made quite obvious by the practical advice

given on all aspects of the subject. Even instructions for maintaining insect cultures for food are given. The sections on capturing escapees and on housebreaking may conjure some humor in readers' minds.

The second part of the book contains a brief discussion of each of the species illustrated on a facing page. In this discussion information is given on general distribution, size, characteristics, natural food, habits, reproduction, occurrence and care in captivity, availability as pets, and suggested foods for captive animals. A surprising amount of general information is condensed on these pages.

While aimed at those with a special interest in monkeys as pets, the book provides mammalogists with a compact general survey of the principal genera of Primates. The plates alone would be well worth having on the shelf.—W. ROBERT EADIE.

Robertson, R. B. OF WHALES AND MEN. Alfred A. Knopf, New York. xii + 300 pp. 1954. Price, $4.50.

This is a book that makes good casual reading for a mammalogist. While much of the book is concerned with a psychiatrist's viewpoints and observations on the men engaged in international whaling in the South Atlantic, there is much information of a fascinating kind on the modern, practical science of whaling and on the whales themselves.

In a chapter called "Brobdingnagian Butcher's Shop" some very graphic data are given on the actual sizes and weights of the various anatomical parts of an 89-foot blue whale (*Sibbaldus musculus*). This creature had a total weight of about 120 long tons and yielded 27 tons of oil. The tongue weighed three tons; the lungs, one ton; the heart, kidneys and stomach, each one-half ton; the liver, one ton; and there were eight tons of blood! Some of the data are made even more graphic by comparisons with familiar things. For example, it is stated that while the skull was about the size of a motor car, the contained brain was not much bigger than a carburetor. Also, there was enough meat to supply a "hamburger" to every person in Boston, Massachusetts (the presumptive implications of this statement are insidious). The cash value of such a whale was estimated at about six thousand dollars.

There are excellent descriptions of the ruthless efficiency of modern whaling and the "factory ship." Such descriptions bring very sharply to the reader the strong necessity for continued international regulation of this great industry if the magnificent mammals on which the industry is based are to survive as species.—W. ROBERT EADIE.

Eadie, W. Robert. ANIMAL CONTROL IN FIELD, FARM AND FOREST. New York. The Macmillan Company, viii + 257 pp. 1954. Price, $3.75.

An obvious need has existed for some time for a book about the control of mammals, including information about their habits, economic status and role in biotic communities. Eadie has ably filled this niche. J. Henderson and E. Craig in their book "Economic Mammalogy", published in 1932, did not discuss specific control measures. The present work brings together and up-to-date the vast amount of widely scattered literature on control procedures and the economy of mammals, and is a valuable addition to the library of a wildlife or economic biologist.

The improvement of this book as compared with earlier works on economic mammalogy is that the author has a good knowledge of wildlife ecology and management and tries to stress the value of applying principles of this science to control measures.

Each species is dealt with under three main headings: "Identification and habits" discusses briefly what is known on the subject today. Under "Economic status" a good deal of information is presented which is not normally available in books about mammals. The section on "Control" discusses actual control practices and techniques as they are in use today. The author stresses in several places that it is much more advisable to try to destroy individuals which actually cause damage rather than whole populations of that species.

The book is very readable for the average person. The author has omitted references to papers in the text, but presents these at the end of a discussion of a group of mammals. This approach greatly improves the readability of the volume, but has perhaps the disadvantage

of not allowing the reader to check quickly possible inconsistencies against the original references. On page 82, for instance, where the author mentions that the depredations of feral cats were observed on a single day by 226 observers, he does not mention what day or time of the year it was, and leaves the reader with the impression that the cats ate birds only. On page 83 it is stated that recent studies revealed that birds made up a smaller portion of the total diet and that small mammals were a large part of the food. However, on page 125 the author remarks that most cats are not good 'ratters' and devote more time to catching birds than they do to rats or mice.

Possibly the author should have presented his own opinion somewhat more. I, for one, would have liked to see him express what *he* considers "beneficial, harmful and neutral" to man's interest and the biological implication of eradication programs of harmful mammals. There is a great deal of public misunderstanding on this subject.

The role of scavengers is properly credited. The absence of illustrations is regretted, especially where a few good drawings would make the procedure of setting certain traps much clearer to the outsider who has no knowledge of the subject. The book lacks up-to-date information on Canadian fur prices.

The control of important species, such as the coyote, meadow mouse, rat, and cottontail is well described and documented. The futility of the bounty system is clearly pointed out in several cases.

As in many publications which bring together scattered information in a rapidly developing field, it is relatively easy to find a few discrepancies: The information about the distribution of the European hare is not entirely up-to-date. On page 58 it should be stipulated that the average price for wolf pelts in 1941 was $18.00 in the United States. The statement on the same page that the prices of these pelts have increased is certainly not true for Canada. I do not concur with the statement that "little is known about beaver diseases, but the mortality rate in general appears to be low". The mortality caused by an epizootic among beaver over vast areas in Canada, and locally in the United States, has been considerable in recent years. As well, I do not find too much justification for the statement that "Where trapping is a principal means of livelihood in the North, the whole economy of the region may be affected by the fluctuating numbers of varying hares."

Perhaps the author should have been more direct in exposing disagreements in census estimates that may be found in the literature. All too often unsound census data are published without comment. On page 75 it is stated that the population of mountain lions in California has been estimated at 600, and that an average of 270 cougars are killed annually. With that rate of kill the population estimate seems very low indeed. On page 227 it is stated that recent estimates have placed the number of white-tailed deer in the United States and Canada at 6,000,000, while on the same page the 1950 population of Michigan alone is reported as 1,000,000 deer. However, it hardly seems fair to the excellent effort of the author to criticize him for these relatively minor details when some of these may be attributed to the original sources consulted.—ANTOON DE VOS, *Ontario Agricultural College, Guelph, Canada.*

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[Reprints of this section may be purchased from the Corresponding Secretary]

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COMMENTS AND NEWS

INCREASED HONORARIA FOR YOUNG MAMMALOGISTS

The American Society of Mammalogists has altered its plan of awarding Honoraria. The amount of each Honorarium has been increased to one hundred dollars ($100.00) and the number available has been reduced to two. These awards may be made for papers submitted to the Committee on Honoraria by young mammalogists who have not yet obtained a Ph.D. degree. The purpose of the awards is to encourage young mammalogists and to stimulate research. Such awards must be used for the purpose of attending and presenting a paper at the annual meeting. The annual meeting for 1955 will be held at the University of Southern California at Los Angeles, June 12–16.

Papers submitted for such awards for 1955 must be in the hands of the Committee by April 1, 1955. All such papers submitted will be reviewed by the committee after that date. Successful applicants will be notified in ample time to make plans for attending the annual meeting.

Send manuscripts to the chairman of the committee, W. Robert Eadie, Fernow Hall, Cornell University, Ithaca, New York.

SYMPOSIUM SEPARATE AVAILABLE

Readers of this Journal may be interested to learn that a paper-bound separate containing ten papers that appeared in the "Symposium on Cycles in Animal Populations" published in the Journal of Wildlife Management, Vol. 18, No. 1, 1954, has been made available. This may be obtained for $1.00 from Dr. D. L. Leedy, Fish and Wildlife Service, Washington 25, D. C.

DATE OF ISSUE OF PREVIOUS NUMBER

Journal of Mammalogy, Vol. 35, No. 3 was mailed August 20, 1954

DEATHS

Deaths of members of The American Society of Mammalogists have been reported as follows: **Richard C. Daetsch**; **Charles T. Ramsden**, Charter Member; and **Harry H. Wehrhane**, Life Member.

THIRTY-FOURTH ANNUAL MEETING

THIRTY-FOURTH ANNUAL MEETING OF THE AMERICAN SOCIETY OF MAMMALOGISTS

JUNE 13–17, 1954

The thirty-fourth annual meeting of the American Society of Mammalogists was held at the YMCA Conference Camp at Estes Park, Colorado, June 13–17, 1954. Sessions were held in the Assembly Hall.

The local committee on arrangements consisted of: Richard G. Beidleman, *Chairman*, Paul H. Baldwin, David H. Canfield, Weldon B. Robinson, Hugo G. Rodeck, Albert C. Rogers.

PROGRAM

SUNDAY, JUNE 13

8:00 P.M.

Directors' Meeting, Administration Building

MONDAY, JUNE 14

8:30 A.M.

Registration, Administration Building Office

9:00 A.M.

Welcome. David H. Canfield, *Superintendent, Rocky Mountain National Park.*

Response. William H. Burt, *President, American Society of Mammalogists.*

1. Wildlife in the national parks. James E. Cole, *National Park Service.*
2. Our mammalian heritage in a changing economy. Donald A. Spencer, *U. S. Fish and Wildlife Service, Wheatridge, Colo.*
3. Mammals of the Colorado cottonwood river-bottom community. Richard G. Beidleman, *Colorado A. and M. College, Fort Collins.*
4. Comparative ecology of six species of wood rats in Colorado. Robert B. Finley, Jr., *Washington, D. C.*
5. Notes on Colorado *Phenacomys* and pikas. William O. Pruitt, Jr., *Arctic Aeromedical Laboratory, Fairbanks, Alaska.*
6. Comments on the zoogeography of the montane mammals of Colorado. Sydney Anderson and James S. Findley, *University of Kansas, Lawrence.*
7. Notes on the pikas (*Ochotona princeps*) from Utah. M. Raymond Lee, *University of Utah, Salt Lake City.*
8. Reproduction in the wolverine (*Gulo gulo*). Philip L. Wright, *Montana State University, Missoula*, and Robert Rausch, *U. S. Public Health Service, Anchorage, Alaska.*

2:00 P.M.

9. Mammalogy and the Arctic Aeromedical Laboratory. William O. Pruitt, Jr., *Arctic Aeromedical Laboratory, Fairbanks, Alaska.*
10. Seasonal changes in the blood picture of active and hibernating ground squirrels. Arthur Svihla, *University of Washington, Seattle.*
11. The electrocardiogram of the raccoon. Charles G. Wilber, *Chemical Corps Medical Laboratory, Army Medical Center, Maryland.* By title only.
12. Some effects of testosterone proprionate-estradiol benzoate combination on reproductive tissues of senescent male hamsters, *Mesocricetus auratus*. Gilbert L. Lescanec and A. L. Soderwall, *University of Oregon, Eugene.* By title only.
13. Effects of radiation on a natural population of the deer mouse (*Peromyscus maniculatus*). W. Frank Blair, *University of Texas, Austin.*

14. The microscopic anatomy of special skin glands in the caribou (*Rangifer tarandus*). W. B. Quay, *University of Michigan, Ann Arbor.*
15. The cervid pelvic girdle in relation to age, sex, and endocrine activity. Richard D. Taber, *University of California, Berkeley.*
16. Comparative morphological observations on the female reproductive tract of some of the lagomorphs. Kenneth L. Duke, *Duke University, Durham, North Carolina.*
17. Final report on studies on the douroucouli monkey language. Ernest P. Walker, *National Zoological Park, Washington, D. C.*

6:00 P.M.

Chuck-wagon barbecue followed by informal get-together

TUESDAY, JUNE 15

8:30 A.M.

18. Possible occurrence of extrasensory perception among lions. Wynant D. Hubbard, *Miami, Florida.* Read by Keith R. Kelson.
19. Rabies infection in insectivorous bats. Colin C. Sanborn, *Chicago Natural History Museum, Chicago.*
20. Some aspects of reproduction in the harp seal, *Phoca groenlandica.* H. D. Fisher, *St. Andrews, New Brunswick.*
21. The development of baits for *Rattus norvegicus*, with special reference to initial acceptability. Harlan R. Shuyler, *Kansas City, Missouri.*
22. Analysis of small mammal remains in barn owl pellets. Edward B. Reed, *Colorado A. and M. College, Fort Collins.*

10:20 A.M.

Annual Group Photograph

10:30 A.M.

Annual Business Meeting, Election of Officers

2:00 P.M.

23. The taxonomic value of the hair of Chiroptera. Frances A. Benedict, *University of California at Los Angeles.*
24. Habitat and systematics of *Nelsonia.* Emmet T. Hooper, *University of Michigan, Ann Arbor.*
25. Subspeciation in the meadow mouse, *Microtus pennsylvanicus*, in Wyoming, Colorado, and adjacent areas. Sydney Anderson, *University of Kansas, Lawrence.* This paper was awarded an Honorarium.
26. Distribution and status of the wolverine in Montana. Fletcher E. Newby, *Montana Fish and Game Department, Kalispell, Montana*, and Philip L. Wright, *Montana State University, Missoula.*
27. Taxonomy of martens. E. Raymond Hall, *University of Kansas, Lawrence.*
28. Mammals of the Sierra de la Madera, Coahuila, Mexico. Rollin H. Baker, *University of Kansas, Lawrence.*
29. A hybrid shrew population. Robert L. Rudd, *University of California, Davis.*
30. Molt in the short-tailed shrew, *Blarina brevicauda.* James S. Findley and J. Knox Jones, *University of Kansas, Lawrence.*
31. The occurrence of *Bison bison* in Florida. H. B. Sherman, *University of Florida, Gainesville.*

3:30 P.M.

Wives and visiting ladies were invited to visit Moraine Museum in Rocky Mountain National Park for an interpretive program by the Park Naturalist.

6:30 P.M.

Annual Dinner, Main Dining Room

WEDNESDAY, JUNE 16

8:30 A.M.

32. Pelage variation and molts in the red squirrel, *Tamiasciurus hudsonicus loquax*. James N. Layne, *Cornell University, Ithaca, New York*. This paper was awarded an Honorarium.
33. Variation in antelope ground squirrels (*Citellus leucurus*). Richard M. Hansen, *University of Utah, Salt Lake City*.
34. Distribution records of the genus *Phenacomys* in eastern North America. Randolph L. Peterson, *Royal Ontario Museum of Zoology and Paleontology, Toronto, Ontario*.
35. An analog computor for population studies. Oliver P. Pearson, *University of California, Berkeley*.
36. On using elementary statistics pertaining to vertebrate populations. George H. Kelker, *Utah State Agricultural College, Logan*.
37. Some aspects of hibernation in the Arctic ground squirrel, *Spermophilus undulatus*. William V. Mayer, *University of Southern California, Los Angeles*.
38. Natural history of the bannertail kangaroo rat, *Dipodomys spectabilis baileyi* Goldman, in north-central New Mexico. Robert Holdenried, *% St. Michael's College, Santa Fe, New Mexico*.
39. Daily variation in activity of *Peromyscus leucopus*. Dana P. Snyder, *Carnegie Museum, Pittsburgh, Pennsylvania*.

10:30 A.M.

Final Business Meeting

2:00 P.M.

40. Common names for American mammals. Donald F. Hoffmeister, *University of Illinois, Urbana*.
41. Studies on potential rodent reservoirs of hemorrhagic fever in Korea. William H. Lawrence, *University of Michigan, Ann Arbor*, and Robert Traub, *Walter Reed Army Medical Center, Washington, D. C.*
42. The ecological importance of skin insensible water loss in *Peromyscus maniculatus sonoriensis*. Robert M. Chew, *University of Southern California, Los Angeles*.
43. Some factors affecting fluctuations of *Microtus* and *Peromyscus*. E. W. Jameson, Jr., *University of California, Davis*.
44. Ecology of Merriam's shrew. Murray L. Johnson, *Tacoma, Washington*.
45. Habitat relations of *Peromyscus maniculatus oreas* and *P. m. austerus* in Puget Sound region. Burton T. Ostenson, *Pacific Lutheran College, Parkland, Washington*.
46. Notes on the breeding habits of *Cratogeomys castanops*. Robert J. Russell, *University of Kansas, Lawrence*.

THURSDAY, JUNE 17

8:45 A.M.

Trail Ridge and Horseshoe Park Field Trips

7:30 P.M.

Beaver Watch

DIRECTORS' MEETING

The meeting of the Board of Directors was called to order by President William H. Burt. Reports of the Treasurer, Auditing Committee, Trustees, and Editorial Committee were read and accepted. In the Corresponding Secretary's report it was noted that of the large

number of members who became delinquent in dues during the year, almost two-thirds were finally reinstated. In view of this fact, the Treasurer and Corresponding Secretary were authorized to continue their present practice of using their discretion in the handling of these members.

The following budget was authorized for 1954:

Expenses of Treasurer	$450.00
Expenses of Corresponding Secretary	450.00
Expenses of Journal of Mammalogy	9700.00
Honoraria for Young Mammalogists	200.00
Expenses of Membership Committee	55.00
Contingent Fund	250.00
Zoological Record	100.00
Index Committee	5.00
Total	$11,210.00

Resignations of H. E. Anthony and W. K. Gregory as Trustees were presented and accepted with regret. Steven S. Gregory was elected as Trustee for the three year term, William P. Harris, Jr., for the two year term, and Colin C. Sanborn for the one year term. W. Robert Eadie was reappointed Editor. The Corresponding Secretary was authorized to take the necessary steps to reduce the large stocks of certain back issues of the Journal of Mammalogy. The four honoraria of $50 each for graduate students were revised to read two honoraria of $100 each for young mammalogists who have not obtained the Ph.D. degree.

ANNUAL BUSINESS MEETING

The first session of the annual business meeting was called to order with 90 members present. Reports of the Corresponding Secretary, Treasurer, and Auditing Committee were read and accepted. The following officers were elected: William H. Burt, President; William B. Davis, Robert T. Orr, Vice-Presidents; Randolph L. Peterson, Recording Secretary; Caroline A. Heppenstall, Treasurer; George C. Rinker, Corresponding Secretary. Directors elected to the 1954–1956 term were: Keith R. Kelson, Donald F. Hoffmeister, Stephen D. Durrant, Antoon De Vos, Hobart Van Deusen. Oliver P. Pearson and Robert H. Coleman were elected to fill the unexpired terms of William B. Davis and Colin C. Sanborn.

The report and recommendations of the Board of Directors were read and accepted. Affirmative action was taken on the recommendation of W. P. Taylor and W. K. Gregory for Honorary Memberships. The report of the Trustees was read and accepted with a special vote of thanks to Dr. H. E. Anthony and Miss Ida Grobe for their efforts in our behalf.

It was with regret that the Society learned of the deaths of four members, one a life member (†), another a charter member (*): Richard C. Daetsch, *Charles T. Ramsden, George H. H. Tate, and †Henry H. Wehrhane.

For the first time in a number of years the Society ended its calendar year with a net loss in its mailing list. Membership increased by only 1.1 per cent (16) and totaled 1423. There were 116 nominees presented for membership, 42 resignations, 4 deaths reported, and 53 members dropped for delinquency for three years in payment of dues. There were 55 new subscriptions, but this was more than offset by 58 cancellations. Again the most encouraging gains have been made in the number of persons beginning life memberships on the installment plan. It is now clear that the installment method of obtaining life membership has been well conceived.

The Corresponding Secretary presented this summary of memberships and subscriptions for 1952 and 1953:

Membership	1952	1953
Changes since preceding annual report		
Nominees	138	116
Resignations	13	42

Deaths reported	9		5	
Members dropped (delinquent)	57		53	
Total	79	138	100	116
Net change		+59		+16
Status as of December 31, 1953				
Honorary members	7		7	
Life members	63		65	
Annual members	1337		1351	
Total membership	1407		1423	
SUBSCRIPTION				
Changes since preceding annual report				
New subscriptions		48		55
Subscriptions cancelled	32		58	
Net change		+16		−3
Total paid subscriptions		447		444
MAILING LIST				
Total membership		1407		1423
Members not receiving Journal	149		166	
Total members receiving Journal		1258		1257
Total paid subscriptions		447		444
Total mailing list		1705		1701
Net change from preceding year		+56		−4

It was pointed out by the Corresponding Secretary that the large number of deliquent members and the failure of members to give prompt notice of changes of address place a wholly unnecessary burden on the finances of the Society and the time of its officers. Deliquencies in payment of dues alone cost the Society more than $60.00 in press charges this year.

The final session of the business meeting was convened June 16, with 72 members present. The reports of the following committees were read and accepted: Conservation of Land Mammals (Ralph S. Palmer); Bibliography (read by Keith R. Kelson); Marine Mammals (read by H. D. Fisher); Nomenclature (Colin C. Sanborn); Membership (Albert R. Shadle); Editorial Committee (W. Robert Eadie); Index (read by Keith R. Kelson); Honoraria for Young Mammalogists (W. Robert Eadie).

Following the report of the Committee on Conservation of Land Mammals, there was considerable discussion of the lack of proof of the reports that rabies in bats has become of serious proportions in the United States. It was suggested and agreed that certain minor changes be made in the report to bring this into proper perspective.

Reports of representatives to the International Union for the Protection of Nature (E. R. Hall) and to the National Research Council (read by Keith R. Kelson) were presented.

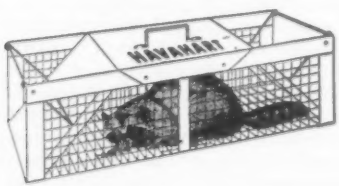
Four resolutions were presented by the Resolutions Committee and passed: (I) *Whereas* the construction of the proposed Echo Park Dam in Dinosaur National Monument would create a definite legal precedent prejudicial to the continued survival of our National Parks and Monuments, and

Whereas there appear to be valid considerations indicating that the Echo Park Dam is not the only solution of the requirements of the Colorado River compact,

Be it resolved that The American Society of Mammalogists, at its 34th annual meeting held in Estes Park, Colorado, 16 June, 1954, urges the appointment by the President of the United States of a qualified non-Federal board for the impartial investigation of the necessity for the invasion of this National Monument.

(II) *Whereas* The American Society of Mammalogists has long recognised the need for having large areas of land remain undisturbed to be used primarily for biological research,
And whereas The American Society of Mammalogists recognizes the psychological and philosophical needs for wilderness areas in America today,
Then therefore be it resolved that The American Society of Mammalogists commends the Wilderness Society, the Izaak Walton League, the Sierra Club, and the National Park Service, for their efforts to establish an Arctic International Wilderness Area in northeastern Alaska,
And be it further resolved that The American Society of Mammalogists urges the proper authorities to take immediate steps to establish such an Arctic Wilderness Area in northeastern Alaska for the main purpose of long-term and undisturbed scientific study of its natural history.
(III) *Whereas* the United States National Park Service, through its representative, has informed the American Society of Mammalogists, at its 34th annual meeting, in Estes Park, Colorado, 14 June, 1954, of the many research programs being conducted on land under Park supervision;
And whereas such research on life histories and ecology of mammals is useful in both the interpretive program and the administration of such lands;
Be it resolved that The American Society of Mammalogists commends the United States National Park Service for the wide range of research projects now approved and hopes that the Park Service will institute and carry on other projects of value to their progress and to the public at large.
(IV) *Resolved:* That The American Society of Mammalogists in session at its 34th annual meeting in Estes Park, Colorado, 16 June, 1954, tenders its sincere thanks and appreciation to the National Park Service and especially to David H. Canfield; to the Estes Park Conference Y.M.C.A.; to the local committee, and especially to R. G. Beidleman, for their hospitality and effective efforts contributing to the success of the 34th annual meeting, and for the enjoyment of all members and their families and friends in attendance at this meeting.

HAVAHART HUMANE ANIMAL TRAPS



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[New names in **boldface** type]

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